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Contents for June 15, 1917

Tendencies in the Zinc Industry

Philosophers long ago observed that life is motion and motion life and that consequently things are always in a state of flux. This is analogy built on the laws of physics, which is the science of motion. As analogies go it is a broad, pervasive and accurate analogy. We may then consider that Newton's three laws of motion govern the world of men, women, and things, as well as the world of mass, velocity and acceleration. Of these three laws, the last, that to every action there is an equal and opposite reaction, applies positively to the zinc business at present; and this law finds its counterpart in Emerson's law of compensation.

In what might be termed the metallurgical economics of zinc these two laws, or rather this law in dual form, applies peculiarly, particularly and precisely. It applies peculiarly for the reason that the zinc business is always in a state of kinetic growth and in actual tonnage there has been but one set-back in twenty years. It applies particularly because in the past two and one-half years there has been a period of abnormal growth or a postive action while the reaction is just starting strongly. It applies precisely because both the action and the reaction can be seen by anyone with extreme clearness.

We know that beginning in January, 1915, a period of intense demand raised the price for spelter which continued with a major swing until June of that year and in its minor swing to the middle of 1916, and that for the past twelve months zinc while low compared with the unprecedented maximum is still nearly double the thirty-year average.

During the first two periods the smelter's margin, which is normally only a few dollars per ton of ore, rose to the unheard-of figure of 70. Now this was enormous. New retort plants were built like six-family tenement blocks, against the advice of the conservatives. Straightway, they paid for themselves in two months. Mines, too, shared in the prosperity, for ore rose in price. New mines paid fabulous dividends. Old mines paid even greater. Never was a boom seen in such glory—never was it so plain. It was a fairy-tale; but the statistics proved its reality. For years to come, professors of economics can use it as the typical and classical boom. Price, production, consumption and smelting capacity broke all records.

Now, in this time of inflation, there were sown the seeds of trouble. Chief of these was labor. Whereas the job of condenser cleaner or "connie-boy" paid in 1897 $1.15 per day, in 1907 $1.65, in 1917 these young

and unskilled laborers received the aristocratic salary of $4.15 a day. All other furnace labor requiring more skill and experience has increased and in three years the cost of labor per ton of ore has doubled. Next after labor, fire-clay has become poorer in quality and higher in price. Coal and gas tell the same story. Now while the smelter's costs have increased his margin has decreased. The consequence is that a number of retort plants have shut down, simply because they saw no prospects of making money in the future and left the field to the newer and more efficiently situated plants.

The smelting plants have made efforts to ameliorate their situation by smelting lower-grade ores, in which there was a large margin. This is reflected in the statistics, which show a steady decline in the amounts of spelter made each year per retort. On the other hand, the capacity of the retort has been increased by reason of "heavy charging" and the use of extra men to chisel out the slag formed in the retorts.

During the last two years the recovery of zinc in the reduction process has been abnormally low. Generally it was better business to force the tonnage, waste some zinc, in order to gain spelter. Losses of 25 per cent and even 30 per cent were not uncommon and not unprofitable, when a furnace was being charged with 22,000 lb. or even higher of oxidized ore, as compared with charges of 16,000 lb. in the earlier days. But to-day losses are often what Mr. Ingalls calls little short of a metallurgical crime.

What the future will bring to the zinc business is an uncertain but interesting proposition. A few things are certain. The first of these is that while furnace labor will gain in efficiency, as indeed it is now daily gaining, it will not be materially cheaper than at present. The metallurgical efficiency, or the skill with which the ore is calcined, blended and mixed with coal, will surely be increased. Fire-clay we know will be improved. Devices like equalizing furnaces with machine molding will be installed. There will be consolidations of existing plants with a general staff of consultation and direction, although the tendency in the zinc business is usually along the lines of individualism. Larger retorts, with machine charging and discharging, will be in cases factors making for amelioration.

As zinc is such an essential raw material for war, we can perhaps expect some sort of government control or supervision to stabilize conditions and make for an increased output. The actual competition of the electrolytic zinc plants and the potential competition of other lines of improvement such as the electric furnace must tend in the run of future time to keep the margin of the retort plant small. As most of the mining and smelting companies have made a great deal of money in the past two years, the funds for developmental work are present.

Perhaps the largest field for the retort plant to save lies in the recovery of values in the residues. The field for this is large and sure. With the recovery of zinc as an oxide, blue-powder or metal, to be sold for commercial purposes, to be used by the electrolytic plant or by the retort plant itself, and with the saving of the values in lead, copper, gold and silver, the economy to the retort plant would be great and appreciatively regarded.

Such an operation would be like the use of the flotation cell in connection with a concentration plant or of the low-pressure turbine in connection with a steam-engine plant.

But we can certainly say that the retort plant is facing the dilemma of increasing costs and decreasing margin. Possibly it is facing a fate similar to that which the steam-engine did twenty years ago. Then the steam-turbine and the gas-engine were coming on the scene. The past decade has told of their success as prime-movers. It is possible that several of the other avenues of zinc-reduction will tell their own story. But just now the retort plant is faced with a hard proposition. And the men making zinc are men and will face in a manly way the action of the great law of compensation. Explicitly, this is that if a man absorbs too much of a colored and flavored solution of ethyl alcohol, the bed will go round at night and in the morning there will be no disputing about the taste of gamboge or sienna in the upper regions of the esophagos. In short, and in physics, to every reaction there is an equal and opposite reaction.

Impurities in Electrolytic Copper Refining

Like all articles in Mr. Lawrence Addicks' remarkable serial on electrolytic copper refining, his article published elsewhere in this issue, on the handling of the impurities in copper refineries, is noteworthy and instructive in more than one respect. It states the problem—or problems involved—very clearly, and likewise the change of the problem with the change in smelter practice. It outlines concisely, with equal clarity, the different solutions of the problem worked out in actual practice, whether arsenic or nickel is the controlling impurity. It also brings out clearly the fact that while copper refining is theoretically very simple in its underlying principle, yet in practice, where all the many little details count, it is a very complicated matter; it is a whole art and science in itself, and we are sure that the whole metallurgical profession will feel under obligations to Mr. Addicks for his truly authoritative critical statement of the present status of this important art and science.

The problem of handling the impurities is absolutely fundamental in all wet processes. The process of the operating man is twofold: first, to get the initial starting conditions of operation right; second, to maintain the conditions right during operation. The first is simple, because the choice of the starting conditions is absolutely in the hands of the operator. The second is difficult, because the operating man has no longer the same free choice; he has a given system, and as soon as electrolysis starts things happen in his system

and his system changes from moment to moment, and new things happen, and so on. By the very rationale of the whole process, impurities will go into the electrolyte. Yet to achieve success, these impurities must be controlled. As David H. Browne once said, everything can be done with pure solutions, nothing with foul ones, and eternal vigilance is not only the price of liberty but of the success of electrolytic processes. No wonder here was a serious handicap, and for a time all wet processes were under suspicion. Anton Eilers, with characteristic frankness, once spoke of wet processes as metallurgical Schweinereien, indicating that the fouling of solutions did not fit his æsthetic ideals of a clear-cut metallurgical process. But, after all, the wet process has won out, at least for metal refining. And while leaching processes are a more difficult proposition, we expect to see interest in them revived when once the full possibilities and limitations of flotation are finally established.

Our Economic Future

Early in January, 1916, Chairman Gary of the United States Steel Corporation issued a statement as to the condition and prospects of the iron and steel industry, saying of industry in general: "There is great expansion at present. I fear there is great inflation." He counseled a "stop, look and listen" policy. Steel prices were then equal to the high prices reached in 1907, the highest since 1902. Now steel prices are $50 per net ton higher. The next month Sir George Paish, editor of the "Statist," and financial adviser to the British Government, furnished an elaborate article to an American paper in which he made what nearly everyone in the United States considered a very remarkable statement: "The idea that the United States is deriving or can derive any advantage whatever from the war is a complete delusion. All that is happening to the advantage of your country is that it is suffering less than the belligerents as a result of this titanic contest."

Now that we are in the war what would Sir George say? What would Judge Gary say now when steel prices are more than double the prices at the time he counseled caution?

When a country engages in successful war it is the patriotism of those who go to the front that saves it from defeat and the practical patriotism of those who stay at home that saves it from economic ruin. There is an immense economic loss in the time and materials consumed in waging war, so great a loss that it could not be made up except by those at home consuming less and producing more. The people must give up their luxuries and waste less. The women must knit socks instead of playing bridge. The children must play gardening instead of playing something useless. Men must work overtime, and so all along the line.

Undoubtedly we are much less selfish now that we are at war. We may feel entirely unselfish, and yet the advent of war does not destroy the personal viewpoint acquired in years. There has been complaint as to the magnitude of the war taxes Congress has been considering on the ground that too much taxation would spoil business and then there would be nothing to tax. Silas Wegg wanted Mr. Boffin to pay for the suppression of the will all that its publication would take from him, but Mr. Venus urged that Boffin ought to be left something to make it worth his while, even as much as half, and Congress has taken an even more liberal view than Mr. Venus. It will still be worth while for business to run along.

War taxes, war loans, and everything else connected with the war should be conducted not to preserve business but to preserve industry. In the practical application there is unfortunately a difference. The question works down to the individual. Matters should be so arranged that every individual should produce the maximum of the most useful things, and should consume, or destroy, as little as possible.

Since the war began there have been real profits for many individuals and there has been an apparent profit to the country as a whole through the favorable merchandise trade balance, some five billions or thereabouts. There is doubt whether this is not partly a paper profit, but what is certain is that the material wealth of the country, if it has increased at all, has not increased as rapidly as it does in peace times. There has been some new construction, but it has been largely for the production of war material, of no value when war is over. The five billions or so by which we have improved our financial relations with the rest of the world is something like 2 per cent of the country's material wealth. During nearly three years of war the retardation the war has caused to the increase in our material wealth has been much greater. Economically we are much poorer than if the war had not come.

Physically we have lost very greatly, just as Sir George Paish said. Mentally we have acquired a great deal but what we have acquired will be no gain unless we use it, of no more economic value than an unworked patent. Many bad habits were acquired. Workmen, given wages at undreamed of rates, have become extravagant. Many business men who acquired wealth dreamed of the ease and luxury that would follow their few years of stress. Our own entrance into the war will largely prove an antidote to these infections. Everyone must work harder and we must endeavor to make materially productive the new ideas the war has given us. Our economic position has been impaired, and work, to balance the waste, is the only thing that will restore it. There is no occasion to worry about the situation immediately after the war. Experience shows that what are called "good times" always follow war. After those "good times" there always come "bad times." The lesson men have never learned before is that there really must be something bad about "good times" if they are followed by bad. The goodness is not entirely of the right sort. Too much of the apparent goodness is made by reckless investing or plain reckless spending. Economy and efficiency need to be continued after the war, that the times may be really good and not store up trouble for the later period.

Readers' Views and Comments

A Great Library of Applied Science

To the Editor of Metallurgical & Chemical Engineering

SIR:—That America has the largest engineering library in the world is excellent. That America should have a large chemical library is manifested in the editorial of your last issue.

It is to be hoped, however, that the ideal of a single large collection of engineering and chemical books should not stop at the gathering together of one single library in one single city. The ideal to strive for upon the completion of a large and, let us say, parent collection, should be for a group of co-ordinated highly technical libraries. By technical libraries I have in mind society, college, public and business house libraries.

Some little time ago, in fact in the *Engineering Record* for March 20, 1915, there appeared an excellent editorial on "The Work of Engineering Libraries." The text of this rather long and to a degree, technical article was summed up in the following: "There are in this country a large group of engineering libraries of great value *collectively*, but not yet suitably *co-ordinated.* Of course the splendid collections of the engineering societies in New York city . . . form a source comparatively accessible to those in the immediate vicinity. In other cities special libraries exist which probably contain unique matter of great value. . . . United effort is just beginning to take effect, and efforts are being made to furnish bibliographical and other information. . . . . *The trouble is that these efforts are generally individual and have not been fully correlated.*"

In the above article is to be found a pointer for a great effort to be launched for the establishment of a suitable powerful directing head with well chosen units throughout the United States.

For some time the writer had kept in mind the article just quoted from the *Engineering Record,* and at every opportunity talked with other librarians doing technical work, either in public libraries or industrial houses, as to the possibility of launching a co-ordinating movement. It was hoped that the Special Libraries Association, composed of librarians in public, college and industrial houses, might officially undertake this work. To that end the writer was asked to read a paper on "Co-operation Between Libraries and the Engineering Profession."

After considering the subject and drawing together facts on paper, the writer sent the first draft to several technical librarians for suggestion and approval. I may be pardoned, then, if I quote the part that appealed to these librarians, on the ground that it has some worth to it. These librarians were, by the way, actively engaged in industrial or society library work.

The part which appealed to them was the summary. To quote, "There should be a committee chosen from this association (the Special Libraries Association, which might now be changed to representative technical librarians, owing to lack of funds for the Special Libraries Association to initiate a committee) with a possible advisory or consulting committee of interested engineers; (2) this committee should work on a roster of sponsored libraries and the published official list distributed widely; (4) the publication of an index of at least the important works of each sponsored collection; . . . . (6) education of the clientele in the use of the established library service; (7) the consideration of a short course based on a study of the practice followed successfully for over two years by Mr. Hendry of the Applied Science Room of the Pratt Institute Free Library, in exchange for the unorganized inefficient instruction now carried on by several of the engineering schools; (9) rounding up of all additional sources of information (other than libraries); (10) well directed publicity."

The greatest strength and usefulness of a "Great Library of Applied Science" lies in a parent library with well chosen units in well distributed localities of the United States.

KENNETH C. WALKER.

Pittsburgh, Pa.

Coming Meetings and Events

American Institute of Chemical Engineers, semi-annual meeting, Buffalo, June 20-22, 1917.

American Society for Testing Materials, Atlantic City, June 26-30, 1917.

American Chemical Society, Boston, Sept. 10-15, 1917.

Third National Exposition of Chemical Industries, Grand Central Palace, New York, week of Sept. 24, 1917.

American Institute of Metals and Foundrymen's Association, Boston, week of Sept. 24, 1917.

American Electrochemical Society, autumn meeting, Pittsburgh, Oct. 3-6, 1917.

American Institute of Mining Engineers, annual meeting, St. Louis, Oct. 8-13, 1917.

Mining Engineers Discuss War Problems

Meeting of New York Section of A. I. M. E.

The New York Section of the American Institute of Mining Engineers held a meeting at the Machinery Club in the Hudson Terminal Building on Wednesday evening, June 6. The meeting was devoted to patriotic addresses and to the discussion of plans for aiding the Government in the present crisis.

A business meeting was held at 6.15 p. m. preliminary to the regular meeting, at which officers were elected for the coming season as follows: Chairman, J. E. Johnson, Jr.; vice-chairman, Edgar Rickard; secretary, D. M. Liddell; treasurer, C. A. Bohn. Dinner was served at 7 p. m.

The first speaker was Major George H. Putnam, retired, who delivered a fine patriotic address. He was followed by Captain Dulieux, a member of the French purchasing commission stationed in New York and also a member of the Institute. Mr. Drucker, a member of the Mining and Metallurgical Institute of London, followed. The last two talks were in the nature of greetings from the allies.

It was decided to continue the meetings throughout the summer, and to take up subjects of importance in the present crisis. Representatives of the Government will be asked to address the meetings in order that ways and means may be found for co-operation. At least two or three meetings are planned for the summer.

An announcement of special importance was made at the meeting by Bradley Stoughton, secretary of the Institute. He said that the Mechanical, Electrical and Mining Societies had decided to entertain Dr. Guglielmo Marconi at a dinner, the date of which will be announced later.

The Court of Appeals Decision in the Miami Flotation Infringement Case

In our issue of June 1 we clearly stated the gist of the important decision of the Court of Appeals in Philadelphia, showing that while the majority opinion of the court, written by Judge Wooley, was technically in favor of the plaintiff (the Minerals Separation) it also appeared to be practically a vindication of the Miami present operating practice, since the three elements which the court decreed as infringing the patents in suit are, in fact, not a part of their present operating practice, but were indeed features of the experimental plant in the experimental stage of the process.

The majority opinion of Judge Wooley, as well as the minority opinion of Judge Buffington, also appear very clearly to sustain the defendant's position as to the limiting character of the U. S. Supreme Court decision in construing patent 835,120 in the Hyde case.

Minerals Separation contended that the Supreme Court had no intention of limiting the patent to any especial violence or duration of agitation, but that its decree was based upon the *critical* amount of oil.

The defendant, upon the other hand, argued that the Supreme Court had found that patentability resided in a combination of the three elements, critical amount of oil, violence and duration of agitation greater than previously disclosed, and resulting froth of a peculiarly persistent character, differing in that from any froth disclosed in the prior art.

As to these conflicting contentions, the majority and minority opinions both seem distinctly to sustain the contention of the defendant, the Miami Copper Company.

Judge Wooley, whose opinion is for the plaintiff (Minerals Separation), technically speaking, since he finds infringement of the patents by the defendant is very clear in his statement referred to in our last issue, "If the only agitation to which the pulp was subjected (after such agitation as in the prior art was necessary to mix the oil and ore) was the agitation of the Callow cells, we would not say that that agitation amounted to or was the equivalent of the violent agitation of the patent disclosure, and constituted infringement; but in the process we are considering, and upon which the decree we are reviewing was based, the Callow cells were not the whole process, but were merely the last of four distinct parts of the process, the other three being the process of the patent or its fair equivalent. Having used the process of the patent in the first three steps in developing the potentiality of the critical quantity of oil and air, and bringing the pulp to a point where, if permitted, it would produce the result of the patent, we feel that the defendant cannot escape infringement by taking an additional step, even though that step, if taken alone, voids the patent."

Judge Wooley clearly indicates here that the Callow cell does not infringe. He also previously stated: "It is equally true that in this fourth step, aeration is direct and is not the result of or caused by agitation. On the contrary, agitation results from aeration, and such agitation, though present in some measure, is not even approximately of the violence and duration of the agitation of the patent. The operation in the Callow cell certainly possesses these distinguishing features from operation of the process where aeration is caused by agitation." Judge Wooley asserts—as the quotation shows—that this expression of the facts is true ("equally true"), the other truth referred to being that the foam immediately subsides upon shutting off the air, and does not arise as it did when "agitation" was arrested.

We do not understand Judge Wooley's statement "that before the Callow cell (or Bubbles tank) is called upon to perform its task, the pulp is always pre-agitated and pro-aerated in some fashion and to some extent." He cannot have overlooked the experiments before the Appellate Court, especially the final experiment, in which the pulp, before charging into the Bubbles machine, was very gently rolled in a bottle so as to produce no froth, and that absence of froth was particularly called to the court's attention. He may have excluded this from his consideration, possibly not having noticed its counterpart in the very voluminous record of the court below, upon much the same principle as he excluded what he calls the fourth process, as he describes the present practice at the Miami mill.

Judge Buffington, in his minority opinion, quotes voluminously from the records and testimony of the discoveries of the process as to the violent mechanical agitation being a requisite. Judge Buffington does not find agitation of this violence or duration in either of the three features considered as infringement by Judges Wooley and McPherson. In everything else they appear to agree.

Contrary to the expectations expressed in our last issue, there has not yet been made, as far as we know, any motion for rehearing or appeal, and it has even been thought possible that there is no necessity for such appeal on the part of the defendant.

Meeting of New York Section of American Chemical Society

The New York Section of the American Chemical Society held its eighth regular meeting of the season in Rumford Hall, Chemists' Club, on Friday evening, June 8. The vice-chairman, Dr. F. J. METZGER, presided in the absence of the chairman, Dr. J. M. MATTHEWS. The meeting and the dinner preceding were very well attended.

Coloring Glass by Short Wave Lengths of Light

The first paper of the evening was presented by HARRY ROSENTHAL of 52 East Forty-first Street, New York City, on a new process of coloring glass by short wave lengths of light, *i.e.*, rays produced by the ordinary quartz mercury arc, an X-ray tube, the Coolidge X-ray tube and a special X-ray tube for producing negative electrons.

Previous writers have recorded the beautiful tint and colors assumed by some grades of glass when exposed to the sun and weather. Photographers had noticed that a different time of exposure was required in taking pictures under skylights as the skylights became old. Experiments showed that the change in color in the skylight glass absorbed an appreciable amount of the actinic rays.

The author's first experiments were carried out about eight years ago with an ordinary X-ray tube and induction coil. A faint color was noticed in the glass after about two days' time. The special water-cooled, self-rectifying tube developed by Dr. Coolidge of the General Electric Company proved a much better apparatus and definite results were obtained with this machine. Following the use of the Coolidge tube a special X-ray machine was used. This latter apparatus has a vacuum tube about 4 in. in diameter, with an anode of solid tungsten supported on a rod of molybdenum, and a cathode consisting of a tungsten spiral which can be electrically heated. The vacuum of this bulb remains constant, the penetration of the tube being governed by the heat of the cathode spiral. Unless

the filament is heated the tube shows no conduction in either direction, even with voltages up to 100,000. In coloring optical lenses a light color can be obtained in two minutes with 100 milli-amperes and 50 kilovolots. In four minutes a medium color is obtained and in ten minutes a dark color. By controlling the penetration of the rays, by varying the voltage, different degrees of color can be obtained.

The author showed several samples of glass colored by this method, including optical wedges and optical lenses of amethyst, amber, green and yellow tints. Some specimens of Kunzite (a semi-precious stone) were also shown which had been changed to emerald green. He stated that porcelain teeth could be colored by placing a wedge of aluminium on the teeth, and that porcelain ware can be colored with designs by placing stencils on it.

The coloring of the glass is believed by the author to be due to a physical change in the material, since by heating the glass will resume its former color. The coloring of the purple glass is undoubtedly due to manganese, and the other colors are analogously obtained.

In discussing the paper Dr. Chas. Baskerville asked whether glass so colored would be of practical use in glasses for furnace work. Mr. Rosenthal replied that the amber-tinted glass was valuable for this purpose. He also stated that amber-tinted lenses were used by the Government for binoculars for use in foggy weather. It was also asked whether the colloidal theory had been considered in connection with the reason for the coloring—that is, whether colloidal metals which would produce the color were set free by the action of the light. Mr. Huston said the term colloid was like the word catalysis. He said the latter word had been defined by a former classmate of his as a phrase used by chemists to hide their ignorance.

Preparation of Pure Molybdenum

The second paper was presented by C. H. HUMPHRIES of the Commercial Research Company, Long Island City, N. Y., on "Molybdenum." His talk was devoted chiefly to the preparation of pure grades of molybdenum.

He reviewed briefly the geology of molybdenum ores and showed samples of molybdenite and wulfenite. Molybdenite, MoS_2, is the principal source of metallic molybdenum. It is reduced by carbon in an electric furnace. The ordinary methods, however, produce a metal which contains some carbide, and in order to obtain pure molybdenum the trioxide or ammonium molybdate has generally been used, as the starting point. The molybdate is made from the sulphide and this is reduced in an atmosphere of hydrogen in an electric furnace, producing a crystalline material which passes through several more stages of purification. The process is analagous to the well known General Electric tungsten reduction process.

This crystalline product is placed in a nickel or nickel-plated boat in a gas furnace and heated to 900 to 1000 deg. C. It is then crushed and screened and reduced again for several hours at 1200 deg. C. It is then examined for oxide by inspection. It appears streaky if oxide is present. If a blue tint is observed on shaking in water oxide is present.

It would be desirable to reduce finally near 1400 deg. C., but there is danger of the material becoming contaminated with iron if a nickel-plated iron boat is used. It is desirable to have less than 0.01 per cent of iron if molybdenum wire is to be made.

After the final reduction the metal is powdered, then pressed in a steel mold and heated in an electric furnace for about a half hour at 1200-1300 deg. The metal sinters and becomes hard, but is not yet suitable for working. It is then placed in a furnace, the air displaced and a current of about 100 amperes is passed through the metal. It shrinks and forms a true molybdenum rod. It is then swaged and made into smaller rods, wire, foil, etc. The swagging is done hot from the electric furnace at about 1400 deg. The metal runs through dies of high speed steel down to 0.001 in. The smallest size for practical purposes is 0.005 to 0.01 in.

If the pure metal is heated to 1200 deg. several times and quenched the surface can be made glass hard.

In discussing the effect of alkalies, the author said that some molybdenite contains calcium and barium, and that these are hard to keep out of the metal. They prevent working of the metal when present even in the hundredths of a per cent.

The author mentioned an interesting possible use of pure molybdenum, *i.e.*, as a substitute for platinum in jewelry. It is just as beautiful and is permanent and can be produced at present for 25 cents per gram. The main drawback is the difficulty of soldering. It can be welded in an atmosphere of hydrogen, but the method is cumbersome. Another possible use is in X-ray targets. The oxide is used with tannic acid in coloring shoes.

In the discussion following the paper Dr. Herty asked whether any jewelry had actually been made from molybdenum. Mr. Humphries said that experiments were in progress, and that he hoped to have definite results to announce before very long. Dr. Baskerville said he had used nichrome wire at the College of the City of New York for the students as a substitute for platinum in making flame tests, and that he was having some molybdenum wire drawn with a thin film of platinum on it for this same purpose. Mr. Humphries said the platinum and molybdenum could be worked very well together.

Metallurgists Needed by the Government

The United States Civil Service Commission announces open competitive examinations for metallurgists as follows:

A vacancy in the Springfield Armory, Ordnance Department at Large, Springfield, Mass., at $3,000 a year, and future vacancies requiring similar qualifications, at the Springfield Armory or elsewhere, will be filled from this examination.

The duties of this position consist in the superintendence of the acceptance tests of steel and oil, and of the heat treatment of dies and tools.

The applicant should have had experience in the chemical analysis and the photomicrographical examination of steel, and in the prescription and supervision of the heat treatment of tools.

A vacancy in the department of ordnance, navy yard, Washington, D. C., at $2,000 a year, and future vacancies requiring similar qualifications throughout the United States will be filled from this examination.

The duties of this position will be the laboratory control of: The melting operations in the manufacture of open-hearth, converter, and electric steel castings and ingots; nonferrous mixtures; the heat treatment of forging and casting of both alloy and carbon steels; the interpretations of physical and chemical tests and their application to shop operations.

Until further notice and on account of the urgent needs of the service, applications will be received at any time and the papers will be rated immediately upon their receipt, in order that appointments may be made with the least possible delay.

This examination is open to all male citizens of the United States who meet the requirements.

Applicants for these positions will not be assembled for examination but will be rated according to their education and practical experience in the subjects designated.

Applicants should at once apply for form 1312, stating the title of the examination desired, to the Civil Service Commission, Washington, D. C.; the secretary of the United States Civil Service Board, postoffice, Boston, Mass., Philadelphia, Pa., Atlanta, Ga., Cincinnati, Ohio, Chicago, Ill., St. Paul, Minn., Seattle, Wash., San Francisco, Cal.; customhouse, New York, N. Y., New Orleans, La.; Honolulu, Hawaii; old customhouse, St. Louis, Mo.; Administration Building, Balboa Heights, Canal Zone; or to the chairman of the Porto Rican Civil Service Commission, San Juan, P. R. Applications should be properly executed, excluding the medical and county officer's certificates, and filed with the Civil Service Commission at Washington as soon as possible.

Third National Exposition of Chemical Industries

The Third National Exposition of Chemical Industries will be held at the Grand Central Palace, New York, during the week of Sept. 24, 1917. Preparations are in active progress, with an advisory committee composed of Chas. H. Herty, chairman; Raymond F. Bacon, L. H. Baekeland, Henry B. Faber, Colin G. Fink, Bernhard C. Hesse, A. D. Little, R. P. Perry, Wm. Cooper Procter, E. F. Roeber, G. W. Thompson, T. B. Wagner, Utley Wedge and M. C. Whitaker. The managers, Charles F. Roth and F. W. Payne, report that the exposition will be larger and more interesting this year than its predecessors. At the close of the past exposition much of the space available on the two floors then used was re-engaged by the exhibitors for this coming exposition. At the present time these floors are completely taken and the greater part of the available space on the third floor has since been engaged.

A large section of exhibits showing the industrial opportunities the South presents in its many raw materials will be known as the "Southern Opportunity Section." A "Paper and Pulp Industry Section" has been provided and many elaborate exhibits are in preparation for the paper men when the Technical Association of Pulp and Paper Industry members visit the exposition again this year.

Other exhibits will be of interest to men from the rubber and textile industries. Many more dyestuffs companies have engaged to exhibit their products than formerly. Many of the chemical and allied industry companies have so expanded their operations in the past year, and their products and interests have become so numerous that they require much additional space to make adequate showings.

The Bureau of Commercial Economics at Washington is this year again preparing many of the motion picture films that will be shown at the exposition, and many exhibitors have now in preparation pictures showing phases in their work in the manufacture of their products. These will be of great interest, inasmuch as many are of processes that have been photographed for the first time, and their first showings will be made at the show.

The program of speakers has not yet been announced, but we are informed that it will be composed of many of the nation's foremost men, and men who have come to the fore in the nation's hour of need.

Osmotic Pressure

Symposium Before Faraday Society

The eighty-third ordinary meeting of the Faraday Society was held on Tuesday, May 1, 1917, in the rooms of The Chemical Society in London. The meeting was devoted to a general discussion on osmotic pressure. Sir Oliver Lodge presided.

Sir Robert Hadfield, president, in opening the proceedings, said he only did so in order to introduce Sir Oliver Lodge into the chair. Speaking as a metallurgist, he hoped that consideration of the subject under discussion would be found to have some bearing on the scientific problems of ferrous-metallurgy, such as the solution of carbon in iron.

Sir Oliver Lodge referred in the first instance to the general importance of the subject in animal and vegetable economy. That was the practical side; but the discussion was to concern itself with the theoretical side. Osmosis depended essentially on molecular discrimination, and this brought it into relation with evaporation and freezing. The subject could be treated either thermodynamically—disregarding what actually goes on—or from the kinetic standpoint, and that was how the authors of the papers would treat it, Dr. Porter applying the gas theory to the dissolved substance, Mr. Bousfield to the solvent, and Dr. Tinker dealing with the matter on a cohesion basis.

Prof. **Alfred W. Porter** opened the discussion by the presentation of his paper.

The investigations of Perrin and others upon Brownian motion have demonstrated once for all that the molecular translatory agitation in a liquid is precisely that which is given by gas theory. This had long been suspected but never proved. In considering a solute the dynamical effects of this motion must be taken into account; when the solution is dilute it comes out equal to the experimental value of osmotic pressure. Any other theory of osmosis must not only explain it, but at the same time must *explain away* the effects of molecular agitation. Of course, when the processes by which the final equilibrium state is set up, or the properties of the membrane which make it semipermeable, come to be examined, many interesting connections will certainly be found which will make it possible to express osmotic pressure in terms of them; but the *causa causans* of the whole phenomenon is the molecular bombardment of the solute, and a knowledge of this provides us with *the only way* in which the value of the pressure has been calculated from any direct theory of the mechanics of the solution. The properties of the membrane form a subsidiary problem; they have as much to do with osmotics as the properties of a glass vessel have upon the origin of the pressure experienced from water contained in it.

The experimental values of Lord Berkeley and Morse and their co-workers for sugar solutions can be approximately represented by a formula of Hirn's type, $P(v - b) = R\ T$; but the values of b are larger than the volume occupied by the sugar itself. The excess can be attributed to water of hydration. The hydration number found in this way from Morse's determinations diminishes with increase in temperature and also with increase in concentration. The extreme values are 53 and about 3. The value 53 occurs only in a very dilute solution, and the corresponding value obtained from Berkeley's experiments is only 14, which seems a more likely number. If the molecules of sugar and water are represented by spheres of volumes equal to their molecular volumes, between 30 and 45 molecules of water would form a single layer on each sugar molecule. It is exceedingly likely *a priori* that the water round a sugar molecule tends to form a condensed layer

on it which will be continually breaking up under the influence of molecular collisions. There is nothing in osmosis to indicate the degree of association of water molecules with each other; mono-, di-, tri-hydrol are indistinguishable.

Doubt is thrown upon the meaning of the symbol N in Poynting's and Callendar's modifications of Raoult's equation. Their theories require that N shall be the total number of real molecules of solvent, whereas thermo-dynamical theory and experiment require that it shall be the number reckoned as of the same complexity as in the vapor state.

Osmotic pressures can be obtained indirectly from vapor pressures by an exact relation first given by the opener; this has been done experimentally by Lord Berkeley. They can also be obtained from latent heats of dilution either by an exact formula given by the opener or by a better-known approximate formula—

$$H_i = u T^2 \frac{\delta}{\delta T}\left(\frac{P}{T}\right).$$

Values of H_i are being determined by D. O. Wood; some of these are published now for the first time, and Morse's determinations are checked by them. This mode of indirect determination of osmotic data is very exact because H depends only upon *deviations* of P from the perfect gas law, being zero when P is proportional to T.

Dr. **F. Tinker** then presented a paper on "The Colloidal Membrane: Its Properties and Its Function in the Osmotic System."

In this contribution the kinetic side of the subject of osmosis is developed by the aid of data obtained from the experimental study of colloidal membranes. Evidence is brought forward to show that moisture flowing through a semipermeable membrane is absorbed or superficially condensed on to the surfaces of the colloidal particles composing the film for such time as it is in contact with the membrane.

Generally speaking, osmotic flow takes place from a pure solvent to a solution because the pure solvent induces a greater pressure of concentration of moisture inside the membrane than the solution does. The condition for osmotic equilibrium is uniformity of moisture pressure and concentration within the membrane. To establish this uniformity, a hydrostatic pressure has usually to be placed on the solution in order to bring the moisture pressure generated by it inside the membrane up to that generated by the pure solvent. The particular hydrostatic pressure which does this is defined as the osmotic pressure of solution.

The evidence adduced points to the conclusion that osmotic diffusion is a process similar in character to, but *not* identical with, the process of vapor distillation. The main difference between the two processes is that the moisture within a membrane is in a much more concentrated condition than it is inside the vapor phase proper. But the resemblance is so great that for purposes of argument and mathematical treatment we can replace the actual membrane by a vacuum; at least this is the case when considering quantities, such as the magnitude of the osmotic pressure, whose value is independent of the nature of the membrane. By means of this simple device the process of vapor distillation becomes a particular type of osmotic diffusion, viz. osmotic diffusion across a vacuum. We can consequently arrive at many of the factors governing the magnitude and direction of osmotic flow, and the magnitude of the osmotic pressure, by considering the factors which determine the relative values of the vapor pressures of the pure solvent and solution respectively. This is done in the latter part of the paper.

Mr. **W. R. Bousfield** then gave his paper entitled "Osmotic Pressure in Relation to the Constitution of Water and the Hydrates of the Solutes."

This paper deals with the subject of osmotic pressure from the standpoint of the ternary constitution of water, which alone can explain the curious fact that for a very dilute solution of sugar the osmotic pressure at 0 deg. C. is greater than that at 5 deg. The vapor pressure theory is shown to be sufficient to explain all the phenomena without postulating osmotic pressure as an "expansive force." It is shown that the osmotic relationships can be deduced with great accuracy on the simple hypothesis that the steam molecules in water behave as a perfect gas in the interstices of the solution. The conclusion is that it is not the solute but the interstitial vapor of the solvent which behaves as a gas, and that it is not the activity of the solute but that of the solvent vapor which is responsible for the phenomena.

He then proceeded to discuss the views put forward by Professor Porter. A theory which left out of account, comparatively speaking, the activity of the solvent, seemed to him the wrong way of looking at things. Criticizing the contention that the diffusion, say, of sugar introduced into a solution indicates an expansive force, he maintained that osmosis might be equally regarded as due to the water expanding in the opposite direction. If the pressure of sugar arose from its thermal motion, why at the surface was it the vapor of the water which escaped and not the sugar? What really obeyed the gas law in solution was not the solute but the occluded vapor comprised in the solution. Figures calculated from his theory agreed with those observed more closely than those deduced from Professor Porter's theory.

Dr. **S. A. Shorter** held that the "gas law" of osmotic pressure, though simple from an algebraical point of view, was very complex from the point of view of the kinetic theory, so that the law formed a very unsatisfactory basis for the theory of the ideal dilute solution. The correct basis for the theory was Henry's law, which stated that the partial pressure of the solute was proportional to its concentration, and which was readily established on theoretical grounds—simply following from the obvious consideration that the field of force, in which each solute molecure moved, was not affected by the addition of further solute molecules. The constant of proportionality depended upon the nature of the intermolecular forces, being vastly greater in the case of, say, solutions of benzene in water than in the case of, say, solutions of methyl alcohol in water. From Henry's law we could readily establish Raoult's law and the "gas law" of osmotic pressure, neither of which could be deduced from simple theoretical considerations, and neither of which contained any reference to intermolecular forces. This latter point constituted a grave defect in the ordinary osmotic theory. Since it ignored intermolecular forces in dilute solutions, it led many investigators to ignore them in concentrated solutions, and to adopt the totally unjustifiable procedure of postulating certain ideal properties of a concentrated solution, and then ascribing departures from this ideal to chemical action (dissociation, association, or solvation). Now, it was evident, from a consideration of the theoretical basis of Henry's law, that intermolecular forces must control the mode of variation with concentration of the partial pressure of the solute in a concentrated solution. The same must be true of the partial pressure of the solvent, and of the osmotic pressure, since they were both related thermo-dynamically to the partial pressure of the solute. Theories of the chemical structure of concentrated solutions, based on the concept of the ideal concentrated solution, were fundamentally unsound.

The most necessary step toward a fuller knowledge of the processes operative in solutions was the further development of the kinetic theory of solution. The points to be explained first of all were not the comparatively minute deviations from some imaginary ideal behavior exhibited by certain solutions, but such broad questions as the existence of different types of partial vapor pressure curves, the total or partial miscibility of liquids, the existence of a critical temperature with respect to miscibility, etc.

The **Earl of Berkeley**, as an illustration of one of the difficulties in the internal vapor pressure theory, referred to the diffusion which would take place if a layer of potassium bichromate were placed at the bottom of a column of concentrated sulphuric acid, the vapor pressure of which was practically nil. He inquired as to the accuracy of the latent-heat method of measuring osmotic pressure.

Prof. **J. C. Philip** stated difficulties he felt with regard to Dr. Tinker's explanation of the selective action of the membrane. As far as size was concerned, a sugar molecule could pass through the pores of the membrane. If the pores had the power of absorbing water, why should not that water absorbed itself take up the sugar molecules, making the membrane "leak"? Recent experimental work on hydration led to somewhat higher figures for the average number of water molecules associated with sugar in solution than the numbers assumed by Mr. Bousfield, namely, from 11 in dilute down to about 7 in strong solutions. Prof. Porter had obtained similarly higher figures.

Dr. **G. Senter**, while agreeing largely with Professor Porter's theory, criticized his views on hydration, and in particular the assumption that the uncertainty in the value of b in Hirn's equation was to be accounted for by hydration.

Mr. **W. C. Dampier Whetham** thought that the relations between osmotic phenomena and vapor pressure and freezing-point which Mr. Bousfield had deduced amounted in effect merely to a confirmation of thermodynamic relations. To get a satisfactory theory of the mechanism of osmotic pressure it was necessary to begin with first principles, and he thought the gas theory the only one which enabled this to be done.

Prof. **A. Findlay**, in a written communication, emphasized the importance of distinguishing between the equilibrium pressure and the process by which this was produced. The process of osmosis and the rôle of the membrane had little reference to the main problem of the value of the equilibrium pressure and its relation to the constitution of the solution. He combated the view that osmotic pressure (a term he thought misleading) was to be identified with the expansive force that brought about diffusion, and he could not accept Professor Porter's kinetic treatment of the problem. The weakness in this arose from the use of the equation $P(v - b) = RT$ in attributing deviations from it to hydration. The connection between heat of dilution and osmotic pressure seemed a fruitful direction for investigation. He favored the view, mooted by Tammann, that osmotic pressure was caused by the inner compression of the solvent in solution. Some recent calculations by Horiba lent support to this theory.

Mr. **J. R. Partington**, in a written communication, showed how it followed from molecular theory that although the physical state of the dissolved molecules might not be comparable with that of the gaseous molecules, yet they could behave with respect to bombardment as if they were in the state of a gas. The question as to whether the osmotic pressure was "caused" by solute or solvent appeared to him to be largely meaningless.

Mr. **F. S. Spiers** (communicated) considered that a satisfactory conception of osmotic pressure was arrived at if one regarded it as the *diminution* in the kinetic molecular energy of the solvent due to association with the solute. This view not only took account of both solvent and solute, but it also gave a simple picture of the process of osmosis, and suggested at once the connection between osmotic pressure and vapor pressure.

Prof. **Alfred W. Porter** replied at this stage to some of the criticisms that had been made. The solute molecules contribute nothing to vapor pressure, simply because when they get near the surface they are drawn downward by the solvent and never succeed in escaping. The answer to Dr. Philip was, he thought, that the canals in the membrane must be narrow compared with the range of molecular action, although not necessarily compared with molecular dimensions. In answer to Lord Berkeley, the method of using latent heat of dilution to determine osmotic pressures gave very considerable accuracy.

Prof. **T. S. Moore** considered that the modification of the gas theory required to explain the action of a solute in solution was so fundamental that it ceased to be a gas theory. The internal pressure of a solution being exceedingly high, it was impossible to suppose that the pressure exercised by the solute molecules could be independent of the solvent molecules and of the forces exerted by the solute on the solvent, which were the assumptions made by Professor Porter. A molecular theory of osmotic pressure must form part of a general molecular theory of solution.

Sir **Oliver Lodge**, in bringing the discussion to a close, pointed out that in a liquid they had to deal with an internal pressure, due to the mutual attraction of the molecules, of great magnitude. The source of osmotic pressure was probably to be looked for in this internal pressure.

Norwegian Company to Manufacture Peat Fuel.—A company is in process of formation in Norway for making fuel from peat by the Rosendahl method. The capital of the company is to be between 600,000 and 1,000,000 crowns (between \$160,800 and \$268,000). The raw material for the new industry will be chiefly peat from the extensive Norwegian moors, but any organic material may be used which is sufficiently abundant in the neighborhood of the factory, *e. g.*, wood waste. The product is said greatly to resemble English coal. Preliminary experiments have been conducted not only in the laboratory but also under factory conditions on a small scale, and the product is stated to have been satisfactorily tested in Christiania households.

University of Wisconsin Summer Session.—The nineteenth annual summer session of the College of Engineering of the University of Wisconsin will be held at Madison during the six weeks period beginning June 25, 1917. Special courses will be given in Chemistry, electrical, steam and hydraulic engineering, gas engines, machine design, mechanical drawing, mechanics, shop work, and surveying. All courses given in the University summer session are open to engineering students. Special courses have been arranged for engineering, manual arts, and vocational teachers. For information, address F. E. Turneaure, Dean, Madison, Wis.

Fellowship in Refractories. — The Refractories Manufacturers' Association, whose headquarters are at 220 South Michigan Avenue, Chicago, Ill., has endowed an industrial fellowship at the Mellon Institute in Pittsburgh.

Annual Meeting of Iron and Steel Institute in London

The annual meeting of the British Iron and Steel Institute was held in London, May 3 and May 4, 1917. An attractive program of technical papers was presented and several interesting announcements were made.

The new president of the Institute is SIR WILLIAM BEARDMORE. Professor HENRY M. HOWE (U. S. A.) was elected an honorary vice-president.

The Bessemer Medal for 1917 was presented to Mr. Andrew Lamberton, in recognition of his work in mechanical engineering appliances in the iron and steel industry.

Following is a list of the papers read at the meeting:

Properties of the Refractory Materials Used in the Iron and Steel Industry. By Cosmo Johns (Sheffield).

The Determination of the Line *SE* in the Iron-Carbon Diagram by Etching Sections at High Temperature *in Vacuo*. By Professor Tschischewsky and N. Schulgin (Tomsk, Russia).

The Influence of Surface Tension Upon the Properties of Metals, Especially of Iron and Steel. By F. C. Thompson (Sheffield).

Cementation by Gas Under Pressure. By F. C. Langenberg (Cambridge, Mass.).

The Penetration of the Hardening Effect in Chromium and Copper Steels. By L. Grenet (Firminy).

The Case-Hardening of Iron by Boron. By Professor Tschischewsky.

Steel Ingot Defects. By J. N. Kilby (Sheffield).

Notes on Some Quenching Experiments. By L. H. Fry (Burnham, Pa.).

Origin and Development of the Railway Rail in England and America. By G. P. Raidabough (Sparrow's Point, Md.).

REFRACTORY MATERIALS USED IN THE IRON AND STEEL INDUSTRY

The author of this paper, COSMO JOHNS, took up a discussion of the sources and properties of the various refractory materials used by the iron and steel industry in England. He said that the art has been so long in front of the science of the refractory industry, that the most urgent need at present is for an expression, in terms of scientific precision, of the most successful practice in manufacturing the refractory product and of the physico-chemical changes which take place when they are used.

"Tenacity and compressive strength at ordinary temperatures are valuable only in so far as they permit the refractory products to be transported and enable them to withstand the structural stresses to which they are exposed when used. This is not difficult to attain. It is when the material is exposed to high temperatures that the value of these properties becomes most important. The abrasion caused by the movement of solid substances while in contact with their heated surfaces is important, while the erosion caused by the passage of dust-laden gases at high velocities become serious in time. Little or nothing is known of the conditions that favor or retard abrasion and erosion. High tenacity, which in most cases would mean that of the bonding or of the most fusible constituents, is most probably the desired property. It is the surface exposed to the highest temperature which suffers, for it is the one that is in contact with the moving solids, liquids, or gases. Compressive strength is rarely a cause of failure, for the bulk of the refractory material is at a lower temperature than the face and therefore less affected. There is, however, urgent need for accurate determination of the two properties under discussion at wide ranges of temperature for the more important materials under both oxidizing and reducing conditions.

"Not less important than resistance to high temperature with concurrent abrasion and erosion is resistance to the corrosion caused by slags gases. The effect of acid slags on basic refractories and of basic slags on acid refractories are familiar, while a most striking example might be indicated on the marked corrosion of the silica bricks in the gas ports and uptakes in open-hearth furnaces, due to the alternating passage of oxidizing and reducing gases with the resulting formation of fusible silicates. A factor conducive to rapid corrosion in the last case is the absence of large particles of silica in the bricks employed and the presence of excessive pore spaces. Here again little has been published and few observations recorded. The effect of the alkalies found in certain coals on the refractories used in coke-oven construction is serious, and here too little is known as to the real nature of the destructive influences at work.

"In the case of coke ovens the retention of gas-tight partitions is absolutely necessary, and this involves the use of a refractory material which does not undergo appreciable volume changes. This means that a mixture of substances with volume changes of opposite sign are employed, viz., clay and silica. But while the contraction of the burnt clay is fairly regular with increased temperatures, quartz, which is the form of silica found associated with it in nature, has an inversion point at which it becomes trydimite. In the presence of certain compounds this inversion takes place at a temperature lower than that at which coking is carried on. In their absence the inversion is retarded and does not take place until a temperature higher than that usual in coking practice is attained.

"Owing to the complex nature of most of the materials used in practice, their properties are not those of the simple minerals of which they are composed, but the resultant of variations which are sometimes of opposite sign and are always varying at different rates. The relative size of the grains employed, the extent of the surface exposed by the more resistant constituents to the others used as bond or matrix, are most important factors in contributing to the ability of the material to perform useful service. Another point of some importance is the influence of mass in promoting or retarding inversions. Some of these inversions take place almost instantly once the critical temperature has been reached, but with others marked hysteresis occurs. Porosity must always occur when the refractory material is composed of more than one constituent, and where their chief volume changes are dissimilar or occur at different temperatures. Little is known of the effect of porosity on the properties of refractory materials. That the pores encourage the deposition of extraneous substances in the interior of the bricks, and that they render the structure permeable to gases, is of course obvious.

"The stresses caused by temperature changes are due to the volume changes which take place during heating. If the refractory material happens to be a good conductor of heat these are not serious, unless one face is rapidly heated and the distortion produced exceeds the tenacity of the material. The remedy available is to avoid rapid temperature changes, and whenever possible to raise the temperature of the material during the burning stage of manufacture well above that at which the inversion to the principal volume change should take place, and to hold it at that temperature long enough for the inversion to be completed. The 'spalling' of magnesite bricks which sometimes occurs has been thus explained, and, it is certain that the excessive expansion of silica bricks would be avoided if the manufacturer could ensure the completion of the quartz-trydimite inversion during burning. Despite the considerable advances in our knowledge of the inversion of silica made recently, their bearing on the problems that face the manufacturer are not yet sufficiently clear.

"The first step—and in all probability the one easiest to take—would be to prepare specifications for the most important refractory products expressed in terms capable of precise measurement or description, basing the specification on the best current practice. This would only be following the excellent example of the gas industry. But specifications at their best only serve to stereotype the best current practice of their day. These specifications should be the starting point of systematic research which should cover, not only the problems that occur during manufacture, but the occurrence in nature and characteristics of the raw materials. Their concentration and purification, proximate and ultimate analysis, mineralogical description and thermal analysis are all points on which additions to our present knowledge would be of great value. But the refractory materials are so complex, and the problems involved are so difficult of direct attack, that any contributions to our knowledge of the properties of the pure minerals, or of the impure aggregates which are used in practice, would be welcomed, even if their immediate application did not happen to be possible."

Leads for Electric Furnaces

By Prof. Arvid Lindström

(Translated from Teknisk Tidskrift, March 7, 1917)

With the increasing size of arc or resistance furnaces the difficulties of conveying the current from the transformer to the furnace have become more pronounced. With electrode potentials of as low as 50 and 100 volts, the current necessarily will be very high, requiring in turn conductors of a large cross-section and under such conditions two difficulties are met with.

One is due to the "skin effect" or the tendency of the alternating current to concentrate in the portion of the conductor nearest the surface; this obviously results in a greater energy loss than would be desirable with a given weight of copper, or a greater weight of copper would be required than would be justified for a certain loss.

The other difficulty is due to the self-inductance of the conductor loop which connects the transformer with the furnace, resulting in a low power factor of this loop, and consequently of the entire installation, with its accompanying disadvantages and additional expenses of different kinds. There are, of course, several types of furnaces (nitrogen furnaces) where a large self-inductance is desired for stabilizing purposes, especially during the starting period, but not even with these does it seem that an inductance inherent and inseparable from the system is desirable.

It is from the above two points of view that the problem of furnace conductors will be dealt with in the following article, and an endeavor will be made to show how the best results may be accomplished when designing the leads, and also how the results may be investigated by tests. As an illustration a known furnace installation will be taken for an example.

I—The Effective Resistance of Large Conductors and Their Proper Arrangement

It has been known for many years that, especially with round conductors, the resistance with alternating current is greater than with direct current, due to the phenomenon known as "skin effect." For round conductors Hospitalier has calculated a table for the ratio

$$\frac{Re}{Ro} = X = \frac{\text{effective resistance with alternating current}}{\text{resistance with direct current}}$$

as function of f and d, where

f is the frequency,

d is the diameter of the conductor in cm. (1 centimeter = 0.3937 inch).

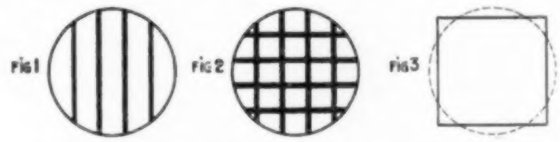
From this table the following values only will be given:

fd^2	X
720	1.32
1280	1.68
2000	2.04
2880	2.39
5120	3.10
8000	3.79

The furnace chosen for the example has a capacity of 900 kilovolt-amperes at the lowest potential of 50 volts, so that the highest current is consequently 18,000 amperes. The frequency is 50. The conductors consist partly of four bars 200 x 15 mm., spaced comparatively close and connected in parallel. This corresponds to a cross-section of 120 sq. cm., or a round solid conductor with

$$\text{Diameter } d = 12.4 \text{ cm.}$$
$$d^2 = 154$$
$$fd^2 = 7700$$
$$\text{and therefore } X = 3.7.$$

With less than one-third of the utilized copper weight it would have been possible to maintain the same resistance and loss if the above skin effect could be avoided. (It may be noted that for 25 cycles X would have been $\sqrt{2}$ times less, thus $X = 2.6$.) It may now be objected that the conductor did not consist of one single solid round conductor. This is true, but it must

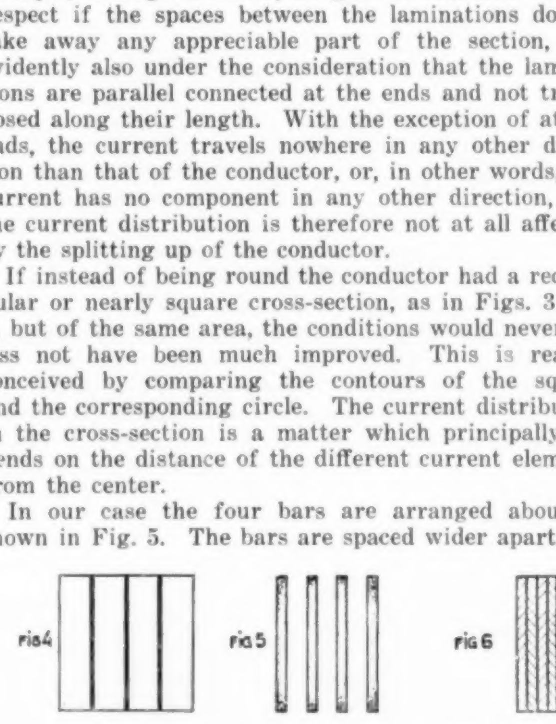


FIGS. 1 TO 3—CONDUCTOR ARRANGEMENT

be remembered that if the conductor is split as, for example, in Figs. 1 and 2, no gain is obtained in this respect if the spaces between the laminations do not take away any appreciable part of the section, and evidently also under the consideration that the laminations are parallel connected at the ends and not transposed along their length. With the exception of at the ends, the current travels nowhere in any other direction than that of the conductor, or, in other words, the current has no component in any other direction, and the current distribution is therefore not at all affected by the splitting up of the conductor.

If instead of being round the conductor had a rectangular or nearly square cross-section, as in Figs. 3 and 4, but of the same area, the conditions would nevertheless not have been much improved. This is readily conceived by comparing the contours of the square and the corresponding circle. The current distribution in the cross-section is a matter which principally depends on the distance of the different current elements from the center.

In our case the four bars are arranged about as shown in Fig. 5. The bars are spaced wider apart and



FIGS. 4 TO 6—CONDUCTOR ARRANGEMENT

the average specific conductivity is consequently less, but not to such an extent that any appreciable decrease of X is obtained. At the same time as this specific conductivity has decreased, the linear dimensions of the cross-section have increased, and without introducing a too great error it may be assumed that the resistance in this case is approximately three times as great for the 50-cycle alternating current as for direct current, or

$$X = 3.$$

Now the question arises: How shall the conductors be arranged in order that a considerably better result may be obtained? The first thing which suggests itself is the use of only one bar, not too thick but much wider, for example 800 x 15 mm., 600 x 200 mm., or 480 x 25 mm.—in any case a bar whose width is 20 to 50 times its thickness, and we will in the following see what value X will get in such a case.

Steinmetz has calculated the current distribution in flat conductors in air. Starting out from the same assumptions, the writer has also calculated the effective resistance of similar conductors. The calculations are not given here, but it may be stated that the results are fully analogous to those obtained for conductors in armature slots.

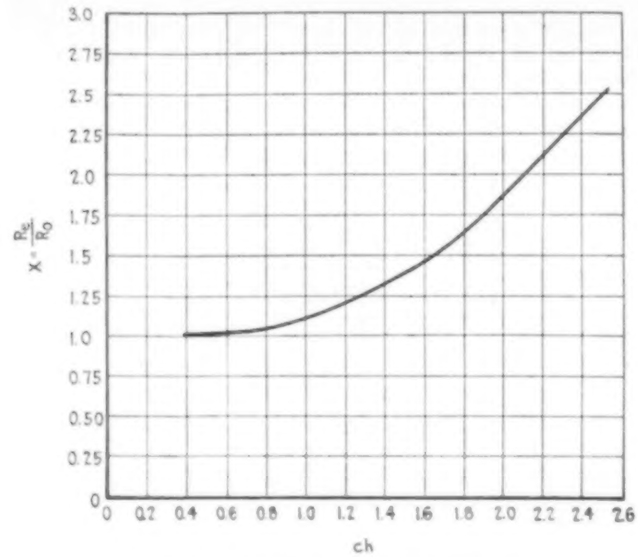


FIG. 6A—DIAGRAM FOR FINDING X

If h = half the thickness of the conductor in cm.,

$$c = 2\pi\sqrt{\mu\lambda f}$$

where

μ = permeability of the material,
λ = specific conductivity,
f = frequency,

then X may be obtained directly from the curve in Fig. 6a. This is on the assumption that the width of the conductor is infinite in comparison to the thickness, an assumption which, while not of course strictly true, may be considered to approximately apply to our case. When

$$\lambda = \frac{1}{2000} \text{ for copper } (c = 0.02)$$
$$\mu = 1 \text{ for copper}$$
$$f = 50$$

Then $c = 1$

is now the thickness $= 2h = 1.5,\ 2.0,\ 2.5$ cm.
then $ch = 0.75, 1.0, 1.25$
and according to Fig. 6a $X = 1.03, 1.09, 1.21$.

In all three cases, but especially in the first and second, a considerable reduction in the loss (about one-third has been accomplished with the same weight of copper. For example, we could use a conductor 500 x 8 mm., or only one-third of the originally assumed weight, and obtain then

$$X = 1$$

that is, the same loss as that now prevailing. Two-thirds of the installed copper could therefore be saved, and the temperature would certainly not be materially higher for this conductor than that of the four bars installed.

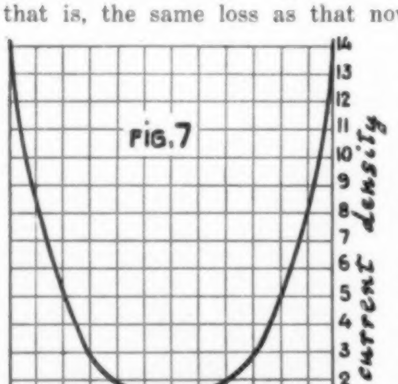


FIG. 7—RESULTS FOR CONDUCTOR OF 60-MM. THICKNESS

If, now, these four bars, Fig. 5, are moved together as shown in Fig. 6, and we treat the 200 x 60-mm. conductor thus obtained as one of considerable width as compared to its thickness, we get $X = 3$. This result may not be considered as exactly correct, but it points in the right direction and checks with that previously obtained.

The effective value of the current density at the distance X from the middle plane of the bar may be calculated from the following equation:

$$i = A\sqrt{2}\sqrt{\cosh 2cX + \cos 2cX}$$

where A is a constant and c has the previous meaning. The result for the conductor with the 60-mm. thickness is given in Fig. 7. The current density nearest the surface is not less than ten times as great as in the center. It is evident that the density varies in the other direction also, so that a concentration will take place both near the upper and lower edges, a condition which is caused by the fact that the width of the conductor is not infinite. In Fig. 5, where an approximate relative view of the cross-section of the actual conductors is given, an attempt has been made to indicate the density in the different parts of the section by shading.

A measurement of the temperature of the bars showed a rise of 32 deg. C. for the two middle bars and 51 deg. C. for the two outside ones, with a current of approximately 14,000 amperes. Considering the poorer radiation of the two former, it is evident that the current in the latter was considerably greater.

Even with the above suggested arrangement with one single bar 500 x 8 mm., a concentration of the current towards the edges must take place, so that even in this case a somewhat increased resistance will result. To avoid this, the conductor may be shaped as a pipe or tube, and if its diameter is fairly large as compared to the thickness of the walls, the calculation used for a bar of infinite width may be applied without appreciable error. With a thickness of 8 mm. the outside diameter of the tube would therefore be $\frac{500}{\pi} + 8 = 168$ mm., this being based on the assumed area of 4000 sq. mm., which is one-third of that installed (12,000 sq. mm.). With this area, on the other hand, the tube could be built with a thickness of 15 mm. and an outside diameter of $\frac{800}{\pi} + 15 = 270$ mm. In that case

$$X = 1.03$$

and consequently the resistance approximately one-third of the present.

Another method would be to arrange the four 200 x 15-mm. bars as shown in Fig. 8, an arrangement which, however, from a practical point of view, appears to be less advisable.

Fig 8

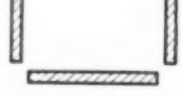


Fig 9

FIGS. 8 AND 9—OTHER ARRANGEMENTS

Instead of an entirely closed tube, it can be separated into two halves as in Fig. 9, but in the former case it is possible to provide for a very effective cooling inside the pipe.

The conductors for the first furnaces of this plant, which were installed a few years ago, were made of closed tubing, but for the more recent units they consist of four parallel connected bars, with the result explained above.

II—The Self-inductance in Electric Furnace Leads and Means for Reducing the Same

The connections between the transformer and the furnaces are made as shown in Fig. 10. The loop in

which the self-induction takes place is *a, b, c, d, e, a*, and this should obviously be made as small as practical conditions will permit, consideration, of course, also being given to copper weight and energy loss. The distances *bc* and *be* are each, as a rule, approximately 3 m. at least. The question then arises, how can the self-induction in such a small loop, consisting of only one turn, reach such a value as to cause undue difficulties? The inductance L in itself is not large, but the voltage drop caused thereby,

$$E_s = 2\pi fLI.$$

This is naturally due to the large value of I, and on the other hand the value seems particularly large when compared to the voltage of the furnace (50 to 100 volts).

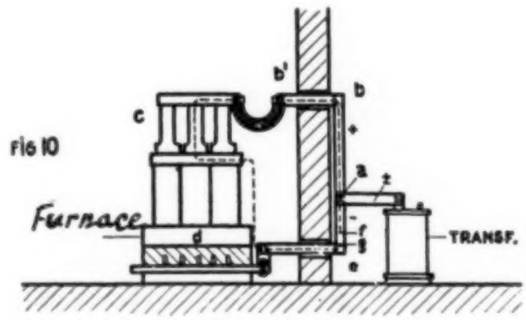


FIG. 10—CONNECTION BETWEEN TRANSFORMER AND FURNACE

By means of the following formulæ, the self inductance of a round conductor forming a circular loop, Fig. 11, can be calculated:

$$L = 4\pi R\left(0.58 + \log_e \frac{R}{r} - \frac{2r}{R}\right)10^{-9} \text{ henry}$$

where

R = the radius of the loop in cm.
r = the radius of the conductor in cm.

If, in Fig. 10,

$$bc = de = l = 300 \text{ cm.}$$
$$cd = be = l_1 = 400 \text{ cm.}$$

and if the rectangular arrangement is assumed to be changed to a circular one with the same circumference, its radius will be

$$R = \frac{2 \times 300 + 2 \times 400}{2\pi} = 220 \text{ cm.}$$

If we also assume that the leads are so heavy and so constructed that the radius of an equivalent tubular conductor is

$$r = 12 \text{ cm.}$$

then the self-inductance will be

$$L = 0.934 \times 10^{-3} \text{ henry.}$$

With a current of 18,000 amperes we get

$$E_s = 53 \text{ volts.}$$

For a rectangular loop it is, however, possible approximately to deduce the self-inductance directly as follows: If the self-inductance for the two opposite parallel sides l are calculated in the usual manner for themselves and similar for the two sides l_1, it is evident that the total inductance of the loop will be approximately equal to the sum of the two, and thus

$$L = 4\left(1 \times \log_e \frac{l_1}{r} + l_1 \log_e \frac{l}{r}\right)10^{-9} \text{ henry}$$
$$= 0.934 \times 10^{-3}$$

or (accidentally) exactly the same value as before. This value is, however, too high on account of the fact that the entire side *cd*, which comprises the electrodes with their holders and the furnace itself, has a considerably greater cross-section (and consequently greater r) than the rest of the circuit. Taking this into consideration and calling the radius (in the equivalent circle) for this side for r_1, then we get

$$L = 2\left(2l \log_e \frac{l_1}{r} + l_1 \log_e \frac{l}{r} + l_1 \log_e \frac{l}{r_1}\right)10^{-9} \text{ henry.}$$

Assuming

$$r_1 = 40 \text{ cm.}$$

we get

$$L = 0.836 \times 10^{-3} \text{ henry,}$$

and

$$E_s = 47 \text{ volts.}$$

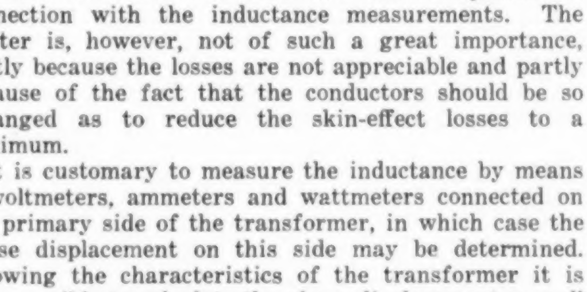
That part of the inductance which is caused by the magnetic field within the conductor itself has been neglected, but when, as previously stated, the current to a greater extent is concentrated near the surface, the error is not appreciable. On the other hand, it may be suspected that the value is too great on account of the fact that the side *be* partly consist of cables which are spread out considerably, in which case r, of course, is greater than assumed even for this part of the loop. Furthermore, these cables sag considerably, which makes the area of the loop less. On account of the many irregularities which the loop presents, it is evident that in general only an approximate result can be expected, and in this particular case possibly a somewhat too large value for the inductance.

III—Measurement of Resistance and Inductance in Furnace Leads

To measure exactly the effective resistance of the furnace leads in our case seems hardly possible. An endeavor to do this was made and will be explained in connection with the inductance measurements. The matter is, however, not of such a great importance, partly because the losses are not appreciable and partly because of the fact that the conductors should be so arranged as to reduce the skin-effect losses to a minimum.

It is customary to measure the inductance by means of voltmeters, ammeters and wattmeters connected on the primary side of the transformer, in which case the phase displacement on this side may be determined. Knowing the characteristics of the transformer it is then possible to calculate the phase displacement as well as the energy and wattless voltage components in the leads. This requires very accurate and often high-potential instruments with current and potential transformers. On the other hand, the inductance in the furnace leads will be combined with the leakage inductance of the transformer, and the latter must therefore be known in order to determine the former.

The writer has therefore—for both reasons—used another more simple and direct method, consisting in measuring the inductive voltage component of the furnace leads directly with a voltmeter. A pressure wire was placed between the loop conductors, as shown by the dotted line in Fig. 10 as well as in Fig. 12, where the dot represents the relative position of the wire with



FIGS. 11 TO 14—ARRANGEMENTS OF MEASUREMENTS AND VECTOR DIAGRAMS

respect to the copper bars. The potential between the ends f and g of this wire was determined by a hot-wire voltmeter, which is the only type of meter which can be used within a reasonable distance from the leads on account of their strong magnetic field. This circumstance is also the principal reason for the difficulty to make measurements, as explained above, on the primary side of the transformer, because even there it becomes difficult to place the sensitive instruments so far away as not to be affected by the magnetic fields. Even if the hot-wire instrument is not a precision instrument, it is at least unaffected by these fields and the directness of the method does not involve any appreciable precision.

With the furnace in question, the following values were obtained:

Current in furnace leads = 13,700 amperes.
Voltage at transformer terminals = 51 volts.
Voltage between f and g = 24 volts.

The current was measured on the primary side of the transformer, also with a hot-wire instrument, and the transformer therefore had to serve as a current transformer in addition.

The voltage triangle is as shown in Fig. 13, so that

$$\cos \phi = \frac{40}{51} = 0.88$$

If the current were 18,000 amperes and the total pressure of 51 volts maintained, the voltage fg would be

$$\frac{18{,}000}{13{,}700} \times 24 = 31.5 \text{ volts},$$

and the voltage triangle as in Fig. 14, or

$$\cos \phi = \frac{40}{51} = 0.785$$

which value would apply for our circuit under full load.

One weakness of this measuring method is due to the difficulty in placing the pressure wire just right, in that it cannot, of course, pass centrally through the electrodes and the furnace itself. The inductance voltage will therefore be a little too low, but in any case it may be assumed that measurements with different arrangements of the leads are sufficiently accurate for comparisons.

An endeavor was also made to measure the resistance component of the pressure drop for part of the circuit. This was done by connecting one terminal of the voltmeter to one of the middle bars at a (Fig. 10) and the other terminal to an isolated wire, which was inserted between points a and b' between the bars as before. The other end of this wire was connected to the same bar at b'. The potential between the two points of the bar was measured to be approximately 1 volt at a current of 14,000 amperes. In order that this shall represent the real resistance drop between points a and b', it is evident that the sum of all the induced e.m.f.'s in the external as well as the internal voltmeter circuit must equal zero. With the strong magnetic field which is caused both by this particular part of the circuit as well as the other parts of the loop, it is hardly possible that this condition can be exactly met, and as its effect would greatly influence the result, it follows that its exactness would be very doubtful, and consequently the value of this method with respect to measuring the resistance comparatively small.

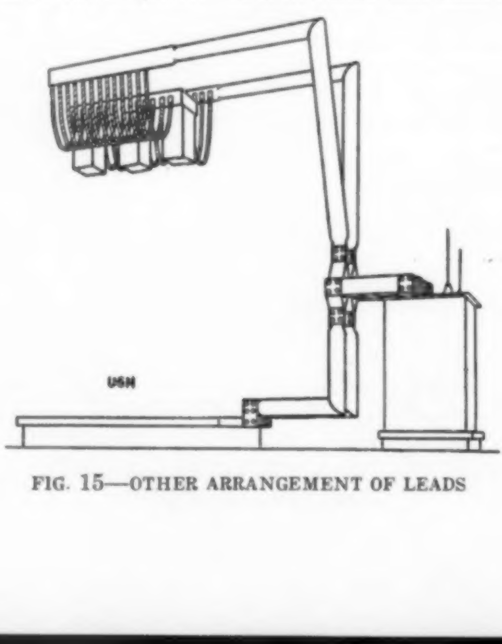


FIG. 15—OTHER ARRANGEMENT OF LEADS

As previously mentioned, this installation also contained some older furnaces, the leads of which consisted of copper tubing instead of bars. The leads were furthermore divided in two branches (tubes) carried some distance from each other, as shown in Fig. 15. A pressure wire was placed in one of the parallel pipes and the following results obtained:

Current in furnace leads = 18,400 amperes.
Potential at transformer terminals = 50 volts.
Potential between f and g (Fig. 10) = 22 volts.

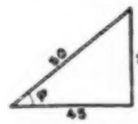


FIG. 16 — VECTOR DIAGRAM

The voltage triangle at 18,000 amperes is therefore as in Fig. 16, and

$$\cos \phi = \frac{45}{50} = 0.9$$

As $\cos \phi$ in the previous case for the same current was 0.785, it is seen that the older method gives considerably better results as far as the inductance is concerned. This depends on the fact that tubes are used instead of the laminated bars, but principally because the lead for each pole is divided in two separate tubes. In these tubes, as follows from the above, the increase in the resistance and the additional losses are considerably less than with laminated bars.

IV—Summary

In those parts of the circuit between the transformer and the furnace where the two leads come near together (for example, between the terminals of the transformer and point a in Fig. 10), there is no difficulty in keeping the inductance or the effective resistance within reasonable limits; for example, by suitably transposing the positive and negative bars. In such cases where the common distance is relatively great, considerable can be gained by making the leads of two concentric tubes. The inductance as well as the increase in the resistance will thus be a minimum.

In those parts of the circuit, on the other hand, where each pole has a separate path, the use of a single group of laminated bars for each lead would, in general, seem unsuitable, and this especially where large cross-sections are involved. As near as possible to the place where the leads separate, each conductor should be divided into two groups, placed sufficiently far apart with respect to the length. With not an altogether too great current, each of these groups may consist of a single bar whose thickness should not exceed 15 to 20 mm. If the current is great, so that for practical reasons a total thickness of the bars for each group of more than 20 mm. would have to be used, tubes should preferably be used instead of bars. Otherwise the arrangements should be as stated above—that is, two tubes for each pole should be used, placed a suitable distance from each other and with a thickness of the walls from 15 to 20 mm. In general, a greater diameter of the tube (and consequently a less thickness of the walls) as well as a greater distance between the groups will give a better result in regard to the inductance as well as to the increased resistance.

It has been the aim to show a method, even if only

approximate, to measure directly the self-inductance and phase displacement of the low-tension furnace leads of a completed installation by means of simple apparatus.

Impurities in Electrolytic Copper Refining

By Lawrence Addicks

Electrolytic refining gives a triple separation of the various impurities in a blister copper anode, distributed in the anode slimes, the electrolyte and the cathode. The chief object of the process is, of course, to make a pure cathode, and secondarily to keep impurities from mounting too high in the electrolyte, in order to keep the cost of purifying the electrolyte within reasonable limits. The ideal process would, therefore, send all of the impurities into the anode slimes, which would then be worked up into various by-products, and the electrolyte would stay of a constant composition. Practically a considerable proportion of the impurities dissolve in the acid sulphate electrolyte, and steps have to be taken for systematic purification of the solution.

Both the problem and the means of dealing with it have greatly changed in the last twenty years. Two decades ago, when electrolytic refining was in its infancy, there were large quantities of black copper to be treated, and many of the smelters were producing pig high in arsenic. An idea of this situation may be gained from some representative analyses of pig copper of that period, given in Table I:

TABLE I—SOME PIG COPPERS ELECTROLYTICALLY REFINED IN 1901

Brand	Arsenic	Antimony	Iron	Sulphur	Lead	Copper
Argentine	0.46	0.40	0.03	0.15	....	96.5
Chicago	0.30	0.19	0.22	....	1.72	96.0
Germania	2.92	0.17	0.01	0.07	....	95.0
Philadelphia	0.86	0.08	None	Trace	....	96.2

This whole situation was changed when the strongly reducing action of the black copper furnace and the practically neutral atmosphere of the copper-producing reverberatory were supplanted by the strongly oxidizing Bessemer converter, and the widespread use of sulphur as a carrying agent for copper brought nearly the whole production through a process which efficiently removed most of the objectionable impurities.

On the other hand, some imported copper pig is of less than standard purity, and there is a steadily increasing production of secondary copper from plants treating junk by the old processes, and they often produce very foul pig. Some representative analyses of these various classes are given in Tables II, III, IV:

TABLE II—ANALYSES OF SOME EXAMPLES OF SECONDARY PIG

Brand	Arsenic	Antimony	Sulphur	Iron	Nickel	Lead	Copper
A	0.03	....	0.94	0.92	0.35	5.49	85.0
B	0.03	0.05	1.02	0.36	0.32	2.68	84.8
C	0.05	0.19	....	0.93	0.47	5.25	82.4
D	0.05	2.25	Trace	Trace	None	12.79	82.6
E	0.05	0.41	....	5.65	1.58	2.02	....
F	0.05	2.63	0.75	5.53	0.33	2.36	84.9

TABLE III—ANALYSES OF SOME FOREIGN PIG COPPER

Country	Arsenic	Antimony	Sulphur	Iron	Nickel	Lead	Copper
Chili	0.10	0.01	0.74	0.99	0.22	0.03	97.4
Japan	0.18	0.12	0.39	0.03	0.06	0.83	97.6
Peru	0.13	0.20	....	0.03	Trace	....	....
Spain	0.11	....	0.60	1.03	0.02	0.13	97.7

TABLE IV—ANALYSES OF NORMAL BLISTER COPPER

Country	Arsenic	Antimony	Sulphur	Iron	Nickel	Lead	Copper
Australia	0.001	0.011	0.224	0.029	0.047	0.003	99.30
Canada	0.037	0.045	0.090	0.050	0.411	0.002	98.80
Mexico	0.017	....	0.260	....	0.040	....	
South America	0.007	....	0.188	0.037	0.044	0.028	99.20
United States	0.008	0.006	0.045	0.034	0.037	0.007	99.30

We have, therefore, the general problems of keeping the impurities out of the refined copper and of working up such of the impurities from the anode slimes and the electrolyte as may show a commercial profit.

The early refineries had much trouble with even the first leg of this proposition, and the uncertainty as to the chemical purity of electrolytic copper produced in the early days had much to do with the premium established in favor of Lake Copper. Arsenic was the chief enemy, and its elimination from the electrolyte became the main metallurgical problem of the plant.

This situation brought about the development of a by-product bluestone plant, fed by systematic withdrawals from the electrolyte, the final mother liquors being precipitated upon iron and discarded.

Then the flood of incoming arsenic abated, and in some cases nickel became the major impurity, bringing about the development of the by-product nickel sulphate plant, the mother liquors being returned to the electrolyte.

In general, one of these two methods of control of the composition of the electrolyte have been used, and they will be examined more or less in detail later on.

The anode slimes were at first cupelled with lead, and only the silver and gold recovered, these being parted by sulphuric acid. Later, lead practice was discarded, except by those plants operated in conjunction with a lead refinery, and much work has been done upon the recovery of selenium, tellurium, platinum, palladium, arsenic, antimony, bismuth, etc. A quite complicated pyro-metallurgy, followed by electrolytic parting, has been developed, and much research devoted to the possibilities of a full wet process.

A discussion of the general question of impurities, therefore, falls under six main headings, namely: (A) sources, (B) exits, (C) distribution, (D) chemical requirements of refined copper, (E) recovery of soluble impurities from the electrolyte, and (F) recovery of insoluble impurities from the anode slimes.

A—Sources

Apart from the entering pig copper there are as many sources of impurities as there are supplies entering the process. While, of course, many of these sources are quite negligible, some are of sufficient magnitude to be worthy of consideration. Among these are fuel, fluxes and acids.

Fuel enters the process at various stages, but the only place where it is of account in this discussion is in the melting of cathodes. Here the various products of combustion and particularly the sulphur have to be reckoned with, as sulphur is one of the principal impurities in refined copper. The discussion of this question falls more normally under the head of chemical impurities in refined copper.

Fluxes include, by a somewhat liberal definition of the word, the materials of which the furnaces are made insofar as they enter the metallurgical slags, the true fluxes, such as limestone and pyrites cinder added in the retreatment of these slags, the charcoal or other carbonaceous covering used to protect molten copper from undue oxidation, bone ash or similar material used to "butter" the molds, and soda nitre and soda ash used as fluxes chiefly in the treatment of the anode

slimes, and the antimonial lead with which the tanks are lined.

Under acids we have sulphuric, nitric and hydrochloric, the last sometimes as sodium chloride. The sulphuric acid is added to make up losses of free acid in the electrolyte in the copper electrolysis and the nitric similarly in the parting plant. The chloride is added to the copper electrolyte chiefly to precipitate antimony as oxychloride, although it has been claimed by many to have positive value as an addition agent.

Fortunately most of these process supplies carry but little in the way of metallurgical impurities. The notable exceptions are blast-furnace fluxes, sodium salts and sulphuric acid.

As refinery slags are always strongly acid, being made by a union of metallic bases with siliceous furnace material, it is necessary to find lime and iron to replace the copper in these slags. The natural source of iron in the vicinity of most refineries is pyrites cinder resulting from the manufacture of sulphuric acid. As arsenic is commonly associated to a greater or less degree with iron pyrites, more or less of this element may be introduced in this manner.

In the same way sulphuric acid made by burning pyrites is likely to contain considerable quantities of arsenic as an impurity, and unless purified acid is used it may be a heavy contaminating agency, since where sulphate salts are made as a by-product the acid purchases are large.

In like manner any nitrate of soda used in the silver building boiling tanks as an oxidizing agent or sodium chloride added to the electrolyte directly bring about a concentration of sodium sulphate which may be objectionable.

B—Exits

A complete analysis of what may be called "exits" for impurities was given in the article "Sources of Metal Loss in Copper Refining" (METALLURGICAL AND CHEMICAL ENGINEERING, July 1, 1916). Based on this, eliminating such items as do not bear directly on our immediate problem, we may classify the exits as (a) outgoing commercial products, (b) slags and (c) stack gases.

The ideal process would eliminate the two latter products entirely and send all of the impurities out as commercial products. Practically not only do several elements escape in their entirety, but excepting copper, silver and gold, the remaining are recovered at far from 100 per cent efficiency.

The tendency to-day is to check stack losses so that in time there will be but two outlets, the one to commerce and the other to the slag dump.

When markets are unsatisfactory some of the products can be stored, as has already been the case with selenium, tellurium and bismuth.

C—Distribution

The distribution of impurities depends partly upon their chemical characteristics and partly upon the metallurgical practice of the individual plant.

In the first place, the cathode will contain measurable quantities of all impurities found in the anodes, although there is room for some discussion as to what proportions of these arrive by electrolytic deposition, by inclusion of electrolyte and by mechanical contamination by anode slimes. (See Addicks, Trans. Am. Electrochem. Soc., vol. xxvi, p. 51.) The percentage of anode impurities found in the refined copper may be seen by direct comparison of average analyses over a long period of operation, as in Table V.

TABLE V—METALLURGICAL EFFICIENCY OF REFINING

Element	Anode	Wirebar	Per Cent of Original Impurity	Efficiency of Refining
Copper	99.030	99.939	......	......
Silver	0.1687	0.00131	0.78	99.22
Gold	0.0051	0.000013	0.25	99.75
Sulphur	0.0075	0.0029	38.60	61.40
Nickel	0.3200	0.0037	1.15	98.85
Lead	0.0567	0.0020	3.52	96.48
Arsenic	0.0523	0.0015	2.87	97.13
Antimony	0.0409	0.0034	8.32	91.68
Bismuth	0.0051	Trace	......	......
Tellurium	0.0282	0.00015	0.53	99.47
Selenium	0.0682	0.00040	0.59	99.41
Iron	0.0181	0.0039	16.10	83.90

The four elements showing a cathode recovery of over 99 per cent are silver, gold, selenium and tellurium, none of which dissolve in the electrolyte. Therefore, the mechanical contamination by anode slimes is less than one per cent. Then we have nickel at 1.15 per cent; this element, while present in oxidized form in the slimes, goes chiefly into solution as sulphate. The same is true of arsenic which, however, forms a light slime which readily attaches itself to the cathode. Lead comes not only from the anodes but from the tank linings, so that the efficiency is not quite true in this case. The same is true in lesser degree of antimony, as hard lead is universally used to-day for tank linings. Antimony is further precipitated from the electrolyte as oxychloride, as previously described, entering the float slime. A characteristic analysis of this sediment is given in Table VI.

TABLE VI—ANALYSIS OF FLOAT SLIME

Element	Per Cent
Copper	3
Arsenic	13
Antimony	30
Bismuth	8
Silver	4
Iron	0.3

When we come to consider the efficiency of refining with regard to iron and sulphur we must remember that both these elements are introduced in the melting of the cathodes, the former in the rabbles and tools used and the latter in the fuel and ladle charcoal, and we also have sulphate sulphur from the electrolyte, so that the figures are misleading.

We may say in a general way, therefore, that the efficiency of refining is very high and that the cathode copper offers a very small outlet for anode impurities; further, that the great bulk of those impurities which are soluble in dilute sulphuric acid will concentrate in the electrolyte.

The balance of the impurities must go into the slimes and we can attempt a measure of this by comparing the assays of the anodes and of the raw slimes as they come from the tanks except for boiling free of soluble salts. This is done in table VII.

The last two columns of table VII assume that 99.5

TABLE VII—CONCENTRATION OF ANODE IMPURITIES IN SLIMES

Element	Anode, per Cent	Slimes, per Cent	Per Cent Anodes x84.4	Per Cent Recovered
Copper	98.14	14.3	....	....
Silver	0.417	35.0	35.2	99.5
Gold	0.00711	0.643	0.600	(107)
Nickel	0.314	5.25	26.5	19.8
Arsenic	0.236	2.68	19.9	13.5
Antimony	0.0906	5.35	7.6	70.0
Bismuth	0.0088	0.46	0.74	61.9
Sulphur	0.0037	1.69	0.31	(541)
Iron	0.0123	0.17	1.04	16.4
Lead	0.0456	2.44	3.85	63.4
Selenium	0.0479	5.70	4.04	(112)
Tellurium	0.0318	2.69	2.68	(100)
Zinc	0.0100	Trace	0.84	None
Insoluble	0.1213	6.60	10.2	64.5

per cent of the silver was in the slimes the remaining 0.5 per cent being in the cathodes. On this basis the recovery in the slimes of the remaining elements has been calculated. Of course, the gold, selenium and tellurium should also show a recovery of about 99.5 per cent, and the discrepancies simply indicate that the correspondence between identity of slimes and anodes is not quite exact.

The sulphur shows a large excess due to the fact that the sulphur in the sulphuric acid of the electrolyte has combined with some of the impurities as sulphates which have not proved readily soluble.

Nickel, iron, zinc and arsenic, as would be expected, show small recoveries; the first three form readily soluble sulphates and arsenious acid is quite soluble in the electrolyte. Nevertheless, with the exception of zinc the slimes retain some of even these elements.

Lead which has a but slightly soluble sulphate, antimony, which is precipitated as oxychloride, bismuth and siliceous matter show high but not perfect recoveries.

Much of this group goes into the float slime which is largely separated out before the heavy slimes are sent to the silver building and this, if corrected for, would make a nearly complete slime recovery.

An analysis of the electrolyte corresponding to the example given above would be about as stated in table VIII.

TABLE VIII—REPRESENTATIVE ANALYSIS OF ELECTROLYTE

Specific gravity	1.226
Per cent free acid	12.03
Per cent copper	2.94
Per cent nickel	1.48
Per cent chlorine	0.0031
Per cent arsenic	0.916
Per cent antimony	0.0350
Per cent iron	0.060
Per cent bismuth	0.0026
Per cent zinc	0.0166
Per cent alumina	0.0595
Per cent calcium sulphate	0.1348
Per cent magnesium sulphate	0.0370
Per cent sodium sulphate	0.5048

A comparison of the relative values of the impurities in the electrolyte with those in the anodes confirms in a general way the distribution already shown. It is evident that in this particular case nickel is the controlling impurity and that any system of purification of the electrolyte which will hold this element at the desired concentration will automatically take care of arsenic and other impurities.

D. The Requirements of Refined Copper

This subject is of sufficient importance to be reserved for treatment at length in a future article.

E. Purification of the Electrolyte

Any system of purification must regularly withdraw sufficient electrolyte to control the amount of the chief impurity. For example, in the analysis given in table VIII, nickel is the element which would first grow to undesirable concentration, although arsenic is a close second and the maximum allowable values of various elements depend upon conditions under which an individual plant is operating. Both nickel and arsenic have been allowed to reach 3 per cent in the electrolyte without disaster in certain local and temporary cases. The first thing is therefore to ascertain what quantity of electrolyte must be daily withdrawn.

I. PURIFICATION BY CEMENTATION UPON IRON

The early methods of purification consisted simply in cementing the copper upon iron and throwing the copper-free liquor away. The scrap iron would be piled in a lead-lined tank, the liquor run in and brought to a boil by heating with steam and at the end of an hour a bright iron rod would not tarnish when introduced, indicating complete precipitation of the copper. The liquor was then run to the sewer and occasional clean-ups of cement copper made.

Theoretically but 0.88 lb. of iron is required to replace one pound of copper. In this case, however, the scrap contained more or less inert graphite and iron oxide, the iron precipitated more or less arsenic, etc., and the high free sulphuric acid actively attacks the iron so that as much as two pounds of scrap iron are often required per pound of copper precipitate.

The cement is generally quite foul running about as shown in table IX:

TABLE IX—ANALYSIS OF TYPICAL CEMENT FROM DISCARDED ELECTROLYTE

Copper, per Cent	Iron, per Cent	Arsenic, per Cent	Silver, Oz. per Ton	Gold, Oz. per Ton
70	5	10	15	0.1

The silver and gold come, of course, from suspended slimes carried over from the electrolytic tanks.

While this method has the advantages of simplicity in operation and small plant required, it makes a foul cement which requires retreatment, runs up a heavy bill for scrap iron and entirely wastes both the free and combined sulphuric acid content of the electrolyte.

Nevertheless, it is still used in some small plants, and is always considered a legitimate emergency measure for dealing with a bad electrolyte.

II. THE BY-PRODUCT MANUFACTURE OF BLUESTONE

The next purification method developed was to go into the manufacture of commercial bluestone, using electrolyte as a raw material. The process consisted of four steps, as shown in Fig 1: Neutralization of free acid by means of anode copper, concentration of neutral liquor by boiling, crystallization of heavy liquor, and cementation of mother liquors.

In this way the entire free acid content as well as that already combined with copper in the electrolyte is recovered as sulphate of copper except that discarded in the final mother liquors.

In this way the iron tanks do not receive any liquor until the impurities have risen to a point where bluestone of commercial purity can no longer be made by fractional crystallization.

Also, as anode copper is used for neutralizing the free acid a certain amount of copper is refined, the silver and gold remaining as slime in the shot towers, and

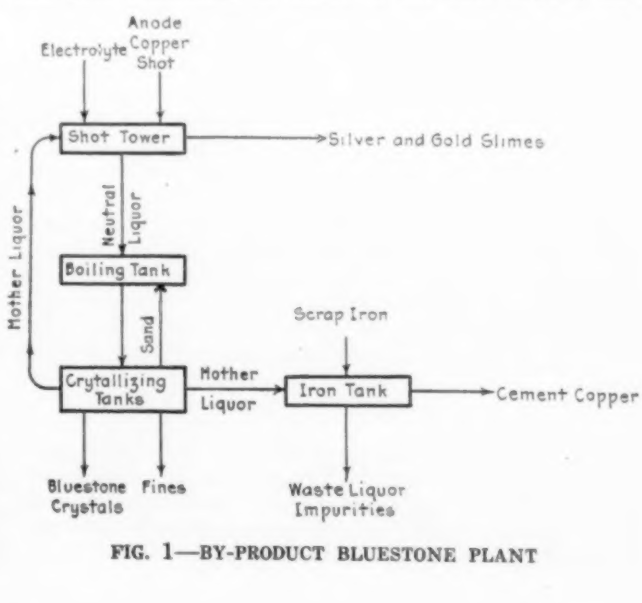


FIG. 1—BY-PRODUCT BLUESTONE PLANT

therefore the by-product plant is entitled to a certain amount of tolls to be credited against its operating expense.

Then there is still the legitimate profit from the market price of bluestone, so that it is possible to place the purification system on a revenue-producing basis.

On the other hand, the plant required is bulky, it is dependent for results upon the market for bluestone which at times is badly overproduced and finally the plant is strictly limited to a predetermined capacity, and therefore uses the electrolyte as a reservoir for fluctuating amounts of anode impurities. Also where very foul anodes are to be treated the bluestone plant becomes enormous.

However, as this system is more or less used to-day, though generally in addition to other methods, some account of the process will be given.

1. *Capacity*

A building 50 ft. by 150 ft. ground plan will produce about 140,000 lb. of bluestone a month. This is equivalent to about 35,000 lb. of copper, but about three-quarters of this comes from the shot copper and only 9000 lb. is from the electrolyte, so that this plant would represent the withdrawal of but 100 cubic feet a day of electrolyte.

2. *Shot Towers*

Copper is not readily soluble in dilute sulphuric acid, especially in the presence of various impurities. In order to promote the rate of solution the liquor is heated and poured over the copper intermittently so as to promote the oxidation of the copper. The towers are built in various ways in order to accomplish this, but the simplest method is to spray the hot liquor over the top of the bed and let it trickle through.

The copper itself is cast in the form of so-called shot in order to increase the surface exposed. Shot is a mass of small hollow irregular spheres, and as these dissolve away, the mass crumbles and this tends to prevent packing. It is made by adding a little matte to an anode furnace charge to lower the pitch and then pouring a thin stream of metal through a blast of air into a well filled with water. More or less minor explosions occur, but if the procedure is skillfully carried out the result is a surprisingly light mass of detached globules ranging from 1/4 in. to 1 1/2 in. in diameter.

Underneath the shot towers is a well, and here the silver and gold slimes wash down as the copper is dissolved and settle out. These are periodically collected and sent to the silver refinery to be smelted along with the anode slimes from the electrolytic tank house. It is impossible absolutely to neutralize the free acid in the electrolyte in this way in a reasonable time, but by repeated circulation at high temperature it is possible to bring it below 1 per cent. The temperature must be above 150 deg. Fahr. for effective work, and the time required is from four to seven days in a plain tower.

3. *Boiling Tanks*

The boiling tanks are lead-lined open tanks with closed steam coils and the liquors from the shot towers are here concentrated as far as steam at a reasonable pressure for lead pipes will carry them. This is about 38 deg. Beaumé and corresponds to 9 or 10 per cent copper. The time required for a batch is about eight hours.

4. *Crystallizing Tanks*

The crystallizing tanks are shallow, open, lead-lined tanks provided with strips of lead hung from cross bars on which the crystals grow. The liquor from the boiling tanks is allowed to stand quiescent in these tanks for five days, which time experience has shown to be the best. A longer period results in more or less resolution, while forced cooling by means of cooling coils results in a crop of small and less pure crystals.

The choice large crystals grow chiefly as trees on the lead strips. At the bottom of the tanks a mass of fine crystals forms.

The crystals are removed after the mother liquor has been pumped out and are then generally dried by hot air and screened to separate the coarse and fine, each class being packed in barrels for shipment. The fine sand is sent back to the boiling tanks and recrystallized.

The best crystals physically are made from truly neutral liquor. Should the liquor carry 2 per cent acid or over, the crystals are likely to be hygroscopic and are not a prime market product. Also calcium sulphate, if present in the liquor to any extent (this salt is sparsely soluble in such solutions), will form white "whiskers" on the crystals.

The main physical question is, therefore, to obtain a maximum proportion of large, clean, dry crystals. An ordinary yield is 47 per cent large crystals, 9 per cent pea and 44 per cent sand.

Chemically the problem is to keep the mother liquor down in impurities to a point where fractional crystallization is sharp enough to make a commercial salt. The alternative is to dissolve and recrystallize. The effect of recrystallizing is shown in table X, where "bottoms" have been dissolved and crystallized, forming crystals and a second crop of bottoms, but leaving most of the arsenic and antimony behind in the new mother liquor.

TABLE X—REMOVAL OF IMPURITIES FROM BLUESTONE BY RECRYSTALLIZATION

	Per Cent Arsenic	Per Cent Antimony
Original "bottoms"	0.434	0.113
New crystals	0.076	0.013
New bottoms	0.117	0.014

$CuSO_4.5H_2O$ contains approximately 25.4 per cent copper, 38.5 per cent combined acid and 36.1 per cent water of crystallization. Ninety-nine per cent crystal should, therefore, run slightly better than 25 per cent copper and 98 per cent slightly less and bluestone is generally considered to carry one-quarter copper. In table XI are given some random analyses of the products from several plants.

TABLE XI—REPRESENTATIVE ANALYSES OF BLUESTONE

Source	Remarks	Per Cent Copper	Per Cent Iron	Per Cent Nickel	Per Cent Arsenic	Per Cent Antimony
A	Coarse	24.97	0.195	0.358	0.018	0.006
A	Fines	24.72	0.215	0.419	0.040	0.009
A	Seconds	23.25	0.250	1.250	0.090	0.017
B	"Anhydrous"	26.18	0.600	1.850	0.668	0.030
C	Coarse	25.22	0.025	0.105	0.003	0.005
D	Coarse	24.80	Trace	....	0.150	0.018

The wide range of the impurities in the different products in table XI is due chiefly to the difference in the electrolytes at the various plants. The salt showing 26.18 per cent copper had been overdried, thereby losing some of the water of crystallization; this makes a dirty white crystal and is also a source of loss to the producer, as copper contents above the guaranteed amount are not paid for.

5. *Mother Liquors*

The mother liquors from the crystallizing tanks are returned to the boiling tanks and reconcentrated with fresh liquor from the shot towers. As the impurities grow in concentration, however, the bluestone is in-

creasingly contaminated and a point is reached where a proportion has to be diverted to the iron tanks to be worked up into cement copper.

Sometimes a foul copper-nickel-iron sulphate is crystallized from such liquors before cementing. An example of such a salt is shown in table XII:

TABLE XII—COPPER, NICKEL, IRON SULPHATE FROM MOTHER LIQUOR

Per Cent Copper	Per Cent Nickel	Per Cent Iron	Per Cent Arsenic	Per Cent Antimony	Oz. per Ton Silver
9.52	11.50	1.19	0.23	0.024	0.15

The silver is, of course, due to contamination by suspended slimes from the shot towers. Similar quantities and a proportionate amount of gold is found in bluestone when anode copper is used for shot. A salt of this character has no commercial use, but is a good starting point for nickel recovery as another by-product.

III. PURIFYING WITH INSOLUBLE ANODE TANKS

Where but little nickel is present and arsenic is the predominant impurity, a simple process based upon the use of insoluble anode tanks is sometimes employed.

A certain amount of electrolyte is diverted to a set of tanks provided with lead anodes and operating in cascade so that practically all of the copper and arsenic are plated out and the equivalent sulphuric acid is liberated. The treated liquor is returned to the electrolyte.

This uses a considerable amount of power, but recovers the acid and calls for no scrap iron. It takes three tanks in cascade to bring the copper and arsenic down to 0.1 per cent or less. The first tank will operate at about 85 per cent current efficiency and produce cathodes, which may with reasonable safety be included in the fine copper output; the second will run at perhaps 50 per cent efficiency and the cathodes reserved for casting copper or anode changes; the last tank runs at a very low copper efficiency and produces a sludge consisting of about half copper and half metallic arsenic. Much of the latter can be eliminated from this by roasting and sublimation, if desired. Such insoluble anode tanks evolve arseniuretted hydrogen, which is very poisonous, and they should therefore be located out of doors.

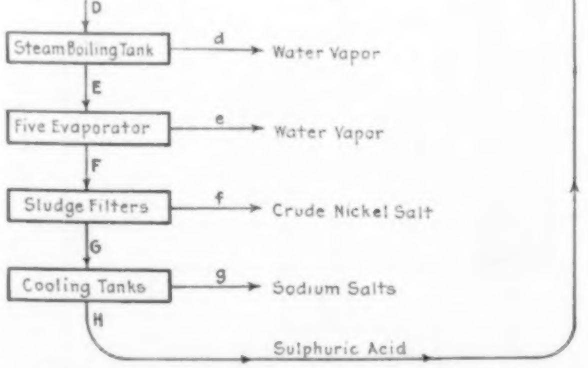


FIG. 2—MODERN METHODS OF PURIFICATION OF ELECTROLYTE

This method is limited by the permissible amount of impoverishment of the electrolyte in copper; if carried to extremes it is evident that the whole copper content of the electrolyte would be withdrawn, the acid being correspondingly increased. On the other hand, when nickel is practically absent from the anodes and the copper withdrawals necessary to hold down the arsenic do not exceed the normal growth of copper in the electrolyte, it is a satisfactory solution of the purification problem.

IV. COMPLETE CYCLICAL PURIFICATION

The method of purification of the electrolyte in general use among copper refineries to-day is shown in diagrammatic form in Fig. 2. Electrolyte is diverted to insoluble anode tanks at a rate just sufficient to keep the determining impurity at the desired point. This impurity is almost always nickel or arsenic and generally the former.

The first step in the process is the same, therefore, as that just described in the preceding paragraph, but the liquor resulting therefrom instead of being returned to the electrolyte is sent to a steam boiling tank where it is concentrated as in the manufacture of bluestone up to about 40 deg. Beaumé.

The liquor is then transferred to a tank made of boiler plate, as, being nearly copper-free and of high sulphuric acid content, it is no longer seriously corrosive to iron. This evaporator is heated by direct fire until the syrup reaches about 70 deg. Beaumé, at which strength practically all the impurities except the small amount of arsenic which has escaped the insoluble anode tanks and the sodium and potassium salts have been precipitated as anhydrous sulphates.

This heavy liquor with its suspended solids is then tapped on to a sand filter where the bulk of the strong acid is filtered out. The mushy salts are then shoveled on to a draining board and finally into a sucking tub, where the acid is displaced with a very small quantity of water.

The partly washed salts are then shoveled on to a drying floor where the water is gradually taken up as water of crystallization and the mass sets into lumps of partially hydrated sulphate, which may be readily handled and shipped and is in good physical shape for charging into a furnace for the recovery of metal values.

If the strong acid filtrate is chilled before returning it to the electrolyte much of the sodium sulphate will be thrown out. Practically this occurs at ordinary winter temperatures at most of the plants.

This process is completely cyclical except for the combined acid sent out with the crude nickel salts and such acid losses as may be incurred by fumes from the fire evaporator. The nickel is recovered in a form reasonably acceptable to a nickel smelter; but little low-grade cathode copper is made, and the arsenic could be separately recovered were it worth while to do so.

The objection still applies that the electrolyte may be robbed of too much copper and this has especial force when discussing nickel, as much of the anode nickel appears to dissolve electrochemically so that more copper is plated out at the cathode than is electrochemically dissolved at the anode.

The remedy, in case of trouble of this character, is to build shot towers and allow a certain proportion of the regular electrolyte to trickle through them. As the solution so diverted has always high free acid content, such towers are more active than in a bluestone plant, where complete neutralization is the object.

The chemical separations are not sharp and some lee-

way has to be left for circulating impurities due to this fact. An example of crude nickel salt made in this way is given in table XIII:

Table XIII—Analysis of Crude Nickel Salt

Per Cent Water	Per Cent Copper	Per Cent Iron	Per Cent Nickel	Per Cent Arsenic
17.0	0.57	1.76	28.45	0.02

F. Recovery of Insoluble Impurities from the Anode Slimes

This question involves the whole metallurgy of the silver refinery and this will be taken up separately in another article.

The Testing of Lubricating Oils

By Hugh K. Moore and G. A. Richter

The selection of the most suitable lubricating oil for plant operation depends upon three things: the specific conditions under which this oil is to be used, the cost of the lubricant and the cost of power.

A lubricant which is ideal for one specific purpose may be entirely unsuitable for service with another type bearing, or may prove very uneconomical in another plant where the cost of power is different. The characteristics of the oil which determine its suitability may be ascertained in many ways, but there is no one machine which will combine all the characteristics to be considered and allow a general conclusion to be drawn regarding its net value.

As inferred above, the significance of test results made on lubricating oils depends entirely upon the "type" of lubrication under consideration, and conversely, the particular form of lubrication which is of immediate interest determines the test methods by which one selects the oil most suitable. Often, depending on the price of power and price of oil, it is wise not to use the best grade of oil to realize most economical results. Many test machines have been designed and built for testing the physical properties of lubricating oils, each serving the particular purpose of the designer.

The experiments and tests which we will refer to in this article were conducted with a type of bearing which measures relatively the durability and also the internal friction or "power consumption" of the oil in question. The apparatus as employed in these tests aims to duplicate that type of bearing in which the oil is present in excess.

A photograph and sketch of this machine are shown in Figs. 1 and 2. It consists essentially of the bearing cone A which is rotated within the conical sleeve B, the desired pressure being maintained by a suspended weight W on the shaft C. The machine is operated by means of a ½-hp. direct-current motor through a gear drive. The conical sleeve is made high enough to use cones of different size and is jacketed in order to maintain any desired temperature either high or low at the bearing surface, and also to provide means for bringing the temperature of the bearing to any selected temperature just previous to each successive run in a series.

The power consumption or friction during the operation is measured by means of ammeter and voltmeter. Knowing the efficiency of the motor, the results obtained by using different lubricating oils in the conical bearing become directly comparable. This comparison may also be realized by operating each time with a predetermined power input. The motor bearings and gear drive are kept lubricated with a large excess of the *same* lubricant all the time, and thus this factor is practically eliminated.

Provision is made for several different methods of testing the oil in question. The revolving cone is furnished with a spiral feeding groove through which the oil may be brought to the bearing surface. The shaft supporting the weights is hollow and allows the oil after feeding through the bearing groove to travel down to a small oil pump which pumps the oil back into the conical bearing, thus completing the cycle. During this operation the desired readings are taken. If the temperature rise of the bearing is of essential importance, a thermometer is suspended in the excess oil over the

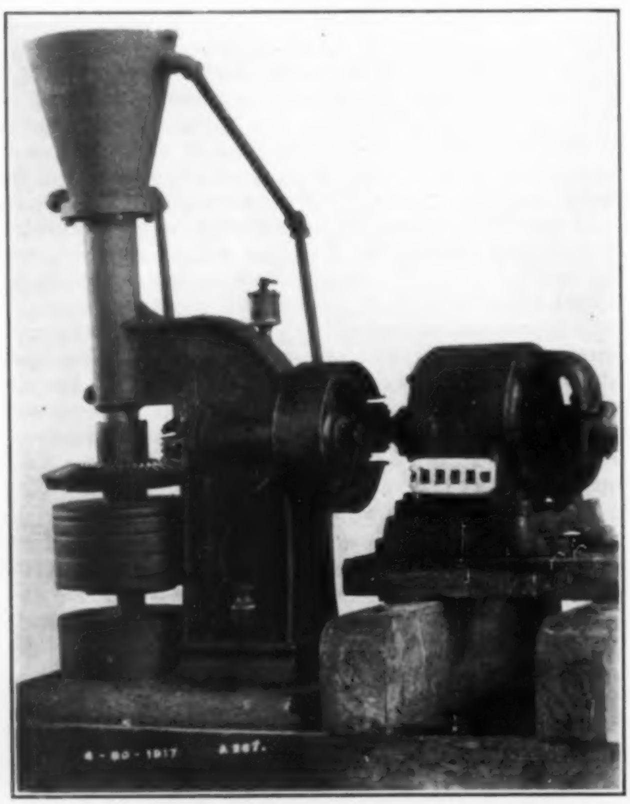


FIG. 1—TEST MACHINE

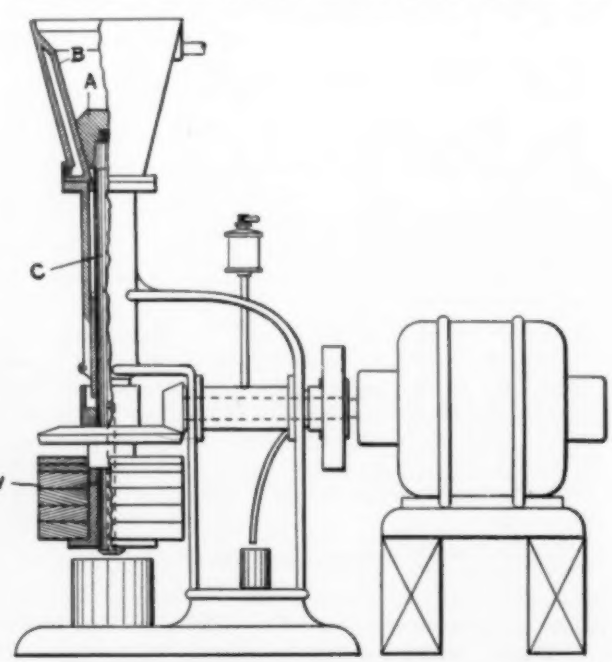


FIG. 2—DIAGRAM OF TEST MACHINE

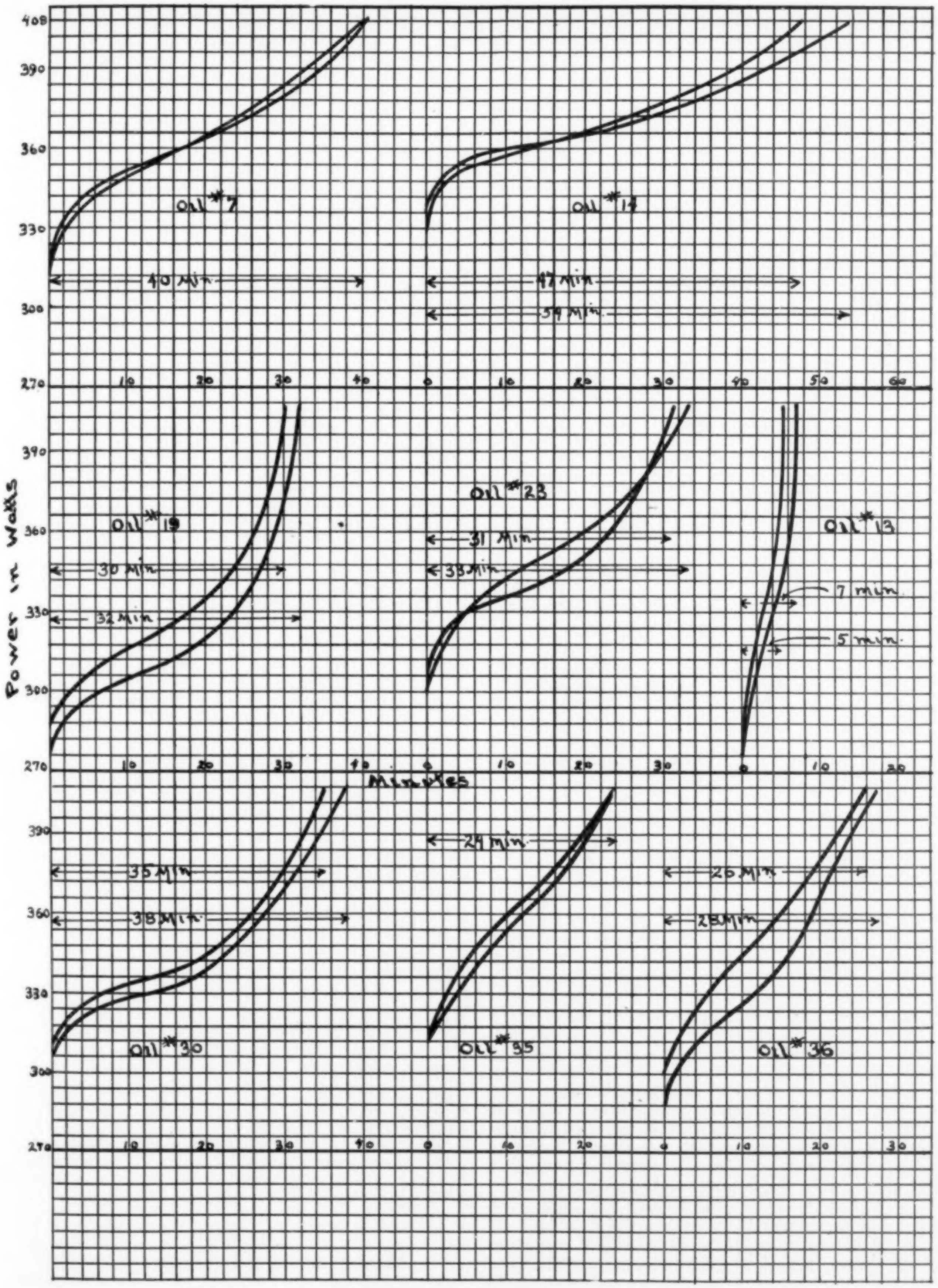


FIG. 3—SUMMARY OF CURVES

bearing. Where the power consumption is the determining factor, the input in watts is plotted against time. In this way the "durability" or "breaking down" qualities of the oil may be studied. If the specific case of lubrication which is being duplicated assumes a given constant temperature, this temperature may be realized by means of the jacket about the bearing. Moreover, the speed, pressure of bearing, and material of

the bearing, may be varied at will to suit the case in question. In carrying out tests as indicated above the authors record:

Material of bearing.
Speed of shaft.
Pressure per square inch.
Type of lubricant.
Initial temperature.
Final temperature.
Curve—power vs. time.
Curve—temperature vs. time.

A second method which may be employed in testing the oil consists in eliminating the oil pump and dropping the lubricant onto the bearing as needed. The oil is regulated by keeping the power input below a predetermined limit and the oil per hour is thus obtained. In carrying out such a test, the lower end of the oil groove in the bearing is first plugged so as to keep the oil from escaping through the groove. A drop of oil is added to the dry bearing and the machine started. When the electrical instruments show the predetermined maximum power input, another drop is added, and the machine allowed to continue to operate until the same maximum power input is registered. The consumption of lubricant per unit time is the basis of comparison.

A third method which may be used in testing the lubricant is to plug the lower end of the groove as before, start the machine without the circulating oil pump, add a certain amount (3 cc.) of oil to the bearing, and record the power input each minute. The machine is allowed to run until a maximum allowable power input is reached, and the power is plotted against time. By studying such a curve one can obtain valuable information regarding the internal friction (power consumption) and also the durability of the oils in question. The authors, for the most part, have employed the last mentioned method of using the machine, although the other methods were also used to advantage.

In carrying out the specific series of runs to be described the operating conditions were as follows: The bearing cone had a vertical angle of 30 deg. The lower end of the feeding groove was plugged with solder. A weight of 100 pounds was attached to the shaft, thus realizing a normal bearing pressure of 1.5 lb. per sq. in. The shaft was operated at a speed of 80 r.p.m. The set includes a series of 8 types of machine oils obtained from different companies. Each run was carried out as follows: The machine was started and three cubic centimeters of the given oil added to the bearing, power readings were taken and continued at intervals of one minute. In this particular series the amperage of the motor was allowed to reach 3.4, whereas the voltage was kept constant at 120 volts. At the end of each run the bearing was cooled to the same starting temperature of about 20 deg. C. by running cooling water through the jacket of the conical sleeve. Several runs were made on each oil for check results. It is to be noted that the absolute number of minutes which is required for the power to reach the above limited amperage is not the only measure of the true value of the oil. To determine the most suitable oil the curves must be plotted and studied with care. The data and curves are given in Table I and Fig. 3.

It is of interest to note that the oil which stands up for the longest period of time without exceeding the allowable power consumption requires a comparatively higher power input *during* that interval of operation than do the other oils which reach the same predetermined maximum in shorter time. This indicates that although the one oil possesses greater durability, most of the other oils require a much smaller power consumption during their time of operation. Before

TABLE I
Machine Oils

Number of Oil	Initial Temperature, Deg. C.	Final Temperature, Deg. C.	Increase Temperature, Deg. C.	Time in Min., Run I	Time in Min., Run II	Average Time
7......	24.0	36.5	12.5	40	40	40.0
13......	26.5	30.5	4.0	5	7	6.0
14......	22.0	38.5	16.5	47	54	50.5
19......	23.0	36.0	13.0	30	32	31.0
23......	25.0	38.0	13.0	31	33	32.0
30......	23.0	37.0	14.0	35	38	36.5
35......	22.0	32.0	10.0	24	24	24.0
36......	20.0	37.0	17.0	26	28	27.0

Note—Normal pressure per square inch = 1.5 lb.
End of groove in cone plugged.
No circulation of oil.
3 cc. lubricant used for each test.
Bearing material = brass.

it is possible to select the most economical oil, it is necessary to know the cost of the lubricant and the cost of power. The most economical oil is not necessarily the most suitable, however, since the factors such as bearing temperature, gumming and cold test must also be considered.

Viewing the problem from an economic standpoint only, and disregarding for the present the other factors mentioned in the preceding paragraph, the general conclusion to be drawn from the above curves is as follows: With the flooded type of bearing (such as used) oil 14 is by far the most durable. Its average power consumption during the long period of operation is, however, greater than the other oils. Oil 19 and oil 30 last for a shorter interval but during that interval the average power consumption is much less. In other words, if cost of power is the deciding factor, then oil 19 and oil 30 are probably more economical to employ than is oil 14, the proportional saving depending on the relative costs of the power and of the oil. Oil 13 and oil 35 appear unsatisfactory in both respects, and unless they possess some other very strikingly redeeming feature not indicated by this test, they cannot be considered in a class with the other test samples.

The investigator may alter his chosen maximum power input and thus slightly modify his numerical conclusion. The object in selecting the maximum load is to duplicate as nearly as possible the allowable frictional load which the local conditions will warrant. As employed above, each type and kind of bearing must be treated in its own individual way, and the investigator must decide on his premise before he may proceed with the test and draw a logical conclusion.

One decided advantage of this form of tests lies in the fact that due to its conical design, even with continued wear, the bearing surface is not altered materially. Practically each individual factor which determines the suitability of a lubricant may be altered at will without disturbing the remaining factors. Thus one can change the speed, pressure of bearing, type of bearing, temperature, or size of bearing each individually or all together. Moreover several types of lubrication may be realized on the same apparatus with but slight change in assembly.

Other oils have also been examined in a similar manner as those above described. Among these were black oils and cylinder oils. The steam jacket was used to advantage in tests on the heavier lubricants.

SUMMARY

(1) An oil tester such as here described proved of value in selecting the lubricant for a specific purpose.

(2) Curves of experimental results are given from which conclusions are drawn.

(3) Other methods of testing oils in this same apparatus are outlined.

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Producer Gas and Its Industrial Uses*

By F. W. Steere

One of the greatest problems now confronting industry is undoubtedly the fuel problem. It is the same old story of prodigal waste until we suddenly find ourselves face to face with a real shortage.

The subject of this discussion is to consider the possibilities of one of the methods of utilizing soft coal, that is, by converting it into producer gas. Producer gas is by no means the panacea for all our ills, but it has its place, and our duty now is to determine to what extent its use can be applied in conserving our natural fuel supplies.

In order to have clearly in mind the distinguishing characteristics of producer gas, we will briefly outline, for the purpose of this discussion, the different kinds of commercial gases most frequently used:

Natural Gas.—Made by secret processes of nature, composed largely of methane, usually running about 1100 B.t.u. per cubic foot.

Oil Gas.—Made by bringing oil in contact with heated surfaces. The resulting constituents and B.t.u. vary for a given oil through a wide range, depending on the temperature of the heated surfaces.

Coal Gas.—Made by the destructive distillation of soft coal in externally heated retorts with the exclusion of air. The resulting coke is withdrawn at intervals, and the retorts recharged with coal. This is the gas most generally made and distributed for domestic use, having a calorific power of approximately 600 B.t.u. per cubic foot.

Coke Oven Gas.—A by-product from the manufacture of coke. It runs somewhat lower than coal gas in B.t.u., but in general may be considered as practically the same. Theoretically the process of manufacture is the same as coal gas, the practical difference being in the size and shape of the retorts.

Water Gas.—Made by the decomposition of steam coming in contact with incandescent carbon, the resulting gas being largely hydrogen and carbon monoxide. This is an intermittent process, as the carbon must be blown, at frequent intervals, with air to bring it back to incandescence.

Carburetted Water Gas.—This is a mixture of water gas and oil gas and is frequently mixed with coal gas and distributed for domestic use.

Producer Gas.—As referred to in this paper, it is the product of an incomplete combustion of carbonaceous material—for the purposes of this discussion—soft coal. It differs from ordinary retort gas in that the whole of the combustible part of the fuel is gasified—no residue or coke is left. The heat required for gasification is obtained from the combustion of a portion of the charge of solid fuel which is to be gasified. Producer gas is almost universally enriched by the use of steam blown through the fuel bed with the air—its use being necessary for the practical operation of the gas producer. The volatile constituents of the resulting gas are carbon monoxide and hydrogen, with about 50 per cent of nitrogen. The calorific power of producer gas from soft coal is ordinarily from 140 to 160 B.t.u. per cubic foot.

It is not within the scope of this paper to discuss the chemistry of gas producer reactions, as these are familiar to all of you. We will rather confine our discussion to the problem arising from the commercial application of the gas after leaving the producer, and the types of furnaces in which this gas can be most effectively utilized.

For many years producer gas has been successfully used in metallurgical work for heating large furnaces, for melting glass, etc. These operations are carried on with hot producer gas, that is, the gas from the producer offtake, which is usually at a temperature of from 1200 to 1400 deg. Fahr., is led directly to the furnaces through brick-lined flues. Producer gas made from soft coal carries large quantities of tar, soot and dust in suspension. It is impossible to keep a large part of this solid matter from being deposited in the flues between the producer and the furnaces. This deposit must be periodically removed by "burning out." The flues are usually so arranged that they may be readily connected to a stack by means of a damper, and, while hot, air is introduced at intervals along the flues, resulting in the combustion of the material deposited. It is obvious that this gas uncleaned, and at a relatively high temperature, could not be conducted for any considerable distance, for instance to a number of small furnaces, without an excessive investment in flues. It would also be very difficult to keep these flues from becoming stopped with the deposits of tar, etc., as the solid matter tends to precipitate much more rapidly as the gas is cooled.

The only practical means for utilizing producer gas in the great variety of heating operations which are found, for instance, in the automobile industry, is to clean the gas completely of all suspended matter and cool it to normal room temperatures. It then can be distributed through any system of piping around a factory, the same as ordinary city gas.

The big problem has always been to make a gas free from both tar and soot. This difficulty of getting clean gas has undoubtedly had more to do with the slow development and adoption of producer gas than all other things combined.

Two general types, or classes, of producers have been developed, the distinguishing characteristics of which are the methods of cleaning the gas:

1. Producers where it is attempted to convert all of the tar to a fixed gas before leaving the producer.

2. Producers which make a tarry gas and rely on outside apparatus for cleaning it.

Suction and pressure producers are found in both of these classes.

The producers of the first-class are built on the theory that if the hydrocarbon vapors, tar oils, etc., which go to make up the very complicated combinations of material that are usually designated as "tar," are brought in intimate contact with highly heated surfaces, these tar constituents will be cracked to fixed gases. The down-draft producers, double-zone producers, and underfeed producers illustrate this class. In these machines the gas is made to pass through the heated portions of the fuel bed, relying on the contact with the incandescent coke to bring about the cracking.

All of the simpler forms of producers, where the fuel is charged at the top and steam and air are blown in at the bottom, come under the second class. The tarry vapors which are distilled from the top of the producers, obviously pass out with the gas and must be cleaned by some external means. This problem of removing tar from gas made in producers of the second class, has been attacked from almost every conceivable angle, such as washing, scrubbing, complicated spray systems, deflectors, centrifugal and whirling machines of almost infinite variety, filtering, pressure and sudden expansion, and precipitation by high-tension electrical discharges.

The high-tension electrical process for detarring gas was invented by the author in 1911. The following extract from a paper* entitled "An Electrical Process for

*A paper read on May 17, 1917, before the Society of Detroit Chemists, Local Section, American Chemical Society.

*METALLURGICAL AND CHEMICAL ENGINEERING, vol. XII, p. 775, 1914.

Detarring Gas," which was read before the American Gas Institute in 1914, describes what takes place in the "ionizer" where the gas is passed through the high-tension electrical discharges:

"An opportunity was provided at the Detroit plant of the Semet-Solvay Company to work out these ideas and develop the theory on which this work is based. This theory, although for from complete, has proven sufficiently accurate to guide us in perfecting a detarring process which is in commercial use to-day.

"In attempting to briefly outline the electrical action, we must keep in mind first that the gas molecules themselves possess both positive and negative electrical constituents which can be separated by X-rays, beta and gamma rays of radium, brush discharge from points, corona discharge from wires raised to high potential, ultra violet light, etc. This process of separating neutral gas molecules into electrically charged parts or ions is called 'ionization.' It is outside the scope of this paper to attempt to discuss the ionic theory, but it should be noted that ions as such are very unstable and cease to exist, that is, recombine to form neutral molecules, almost the instant they are outside the ionizing influence. A very few molecules are continually splitting up, presumably because of the trace of radioactive substances found in most gases as well as in the atmosphere.

"Professor Millikan of the University of Chicago has studied the movements of a small drop of oil between two oppositely charged condenser plates when attacked by atmospheric ions. The drop receives a charge when atomized, so by throwing on and off the electrical field, the drop is made to beat up and down between the plates. The instant an ion attaches itself to the drop the fact is made known to the observer by its change in speed, this change depending on the sign of the ion and the charge on the drop. The important and interesting thing to note is that with over a thousand drops studied in this way, the change of speed was always exactly proportional to the number of ions attached to the drop.

"Let us recall that there are about 27,000,000,000 molecules in 1 c.c. of ordinary air and that each molecule may be separated into at least two ions. When just one of the possible 54,000,000,000 ions per cubic centimeter attached itself to the oil drop it instantly caused an appreciable change in its velocity. Imagine then the violence with which this drop would have been thrown about if all the molecules surrounding it had been ionized.

"This is just the condition we bring about in the electrical detarrer. The gas carrying the minute tar globules is swept into an intense ionizing field. Billions of gas molecules on every side are being torn apart. The resulting ions rush madly about in their effort to recombine. The unsuspecting tar globules find themselves in a storm center of unseen forces hurling them in every direction. The time occupied in the passage of the tar particles through the electric field is brief and it might naturally be supposed, as it heretofore has been, that an aimless to-and-fro movement of them would be the result of the applied energy. It would, however, be hard to conceive of a condition more favorable to impact between tar particles, and experience shows that either because of this impact, or for some reason as yet unknown, agglomeration results and the dense tar mist is almost entirely dissipated, leaving a relatively few large tar drops in its place. This rather figurative description will seem more real to those who have witnessed this remarkable phenomenon within a glass vessel filled with dense fumes or fog. The instant the current is turned on, the whole field can be seen to clarify. The commercial importance of this becomes more apparent when we realize that this action can be brought about at almost any desired temperature.

"No attempt is made to free the gas of these agglomerated tar particles while it is still in the ionizing field. The apparatus is so arranged that everything is swept on through into some form of mechanical extractor where a complete removal is affected with very little power loss. The Doherty Centrifugal Tar Extractor worked very well to accomplish this; the old type P and A machine also became a very efficient tar extractor when placed after the ionizer.

"The whole process may be summed up in this: It is practically impossible to free the gas from tar in the extremely fine state of subdivision which naturally results from rapid condensation. There is no difficulty in removing relatively large drops and the electrical treatment simply converts the fine mist into the large drops."

Enormous sums of money have been expended in attempting to perfect a commercial process, that is, a process which would deliver clean gas of uniform calorific power continuously. The great difficulty which has always been met, lies in the fact that the success of any gas-making process depends almost entirely, you might say, on the skill with which it is operated. Machines and processes may give perfect results in the hands of the inventors or skilled operators, but when they are sold promiscuously and are handled by unskilled or indifferent operators, the result is failure. This has been the history of the gas producer development for years past, with the result that all clean gas producer development work is looked upon with a great deal of suspicion.

Let us confine our attention to the application of clean, cold producer gas to some of the heating operations which are generally done with other fuels, such as oil, for example. We will first run over, briefly, the types of furnaces which may be adapted to the use of producer gas. These can best be discussed under the following headings:

Double Regenerator.
Single Regenerator.
Double Recuperator.
Single Recuperator.
Combination Regenerator and Recuperator.
Simple furnace where no waste heat is recovered.

For the purposes of this discussion, we will define regeneration as a reversing process, in which the gas or air, or both, to be heated, is first brought in contact with heated surfaces, usually checkerwork, which, in the previous cycle, has been heated by being in contact with the heated products of combustion leaving the furnace. This is the old Siemens process with which you are all familiar.

We will speak of recuperation as the non-reversing process where the products of combustion give up their heat to the incoming gas and air by conduction and radiation through the flue walls. The incoming and outgoing gases are always kept in separate flues.

It is possible to obtain a higher furnace efficiency with producer gas firing and double regeneration than it is possible to obtain with oil. The reason for this possible high efficiency is that the sensible heat of the products of combustion is just about equal to the quantity of heat required to raise the gas and air for combustion to the same temperature as the products of combustion leaving the hearth.

To illustrate—assume a double regenerative furnace working with a hearth temperature of 1650 deg. Fahr. There will be enough heat in the products of combustion to raise the temperature of the incoming gas and air to 1650 deg. Fahr. at the top of the regenerators.

When burning oil, on the other hand, double regen-

eration obviously is impossible. The sensible heat of the products of combustion is greatly in excess of the heat required to raise the air to the temperature of the products of combustion, and very little heat can be taken up by the oil. The balance of the sensible heat from the products of combustion must necessarily be wasted.

Double regeneration with coal gas is not advisable. The hydrocarbon vapors carried in the gas, when brought in contact with the hot checkerwork, are cracked to hydrogen and carbon, the carbon being deposited as soot in the checkerwork. We can see no reason why single regeneration cannot be used with considerable saving, but have no experimental data on this possibility.

Generally speaking, it will not be practicable to build regenerators which would bring about a perfect transfer of heat. In order to demonstrate how far heat recovery could be carried, however, we built an experimental furnace in which the products of combustion leaving the bottom of the regenerators were kept within from 10 to 15 deg. of the temperature of the incoming gas and air. During the test which was run for two days, the products of combustion leaving the furnace were at no time above 85 deg. Fahr. This, of course, was not commercially practicable, as the cost of such a complete saving of the heat was more than the heat was worth. The average stack temperatures of our commercial furnaces are around 175 deg. Fahr., very rarely going over 200 deg. Fahr. We might say that in all of our work, we have found that it is a comparatively simple matter to build apparatus which will save heat, but it is a real achievement to build apparatus that will save heat and money at the same time.

It will be noted that the above discussion applies only to the double regenerative furnace. When firing with producer gas, and using only single regenerators, there must necessarily be a loss of approximately 40 per cent of the sensible heat of the products of combustion leaving the hearth, which are wasted to the stack.

To illustrate the possibilities of producer gas firing, we will describe a set of furnaces which we have designed and built for the Ford Motor Company at Detroit, for heat-treating front axles. Three heat treats are required. After the first heating, the axles are allowed to cool in the air by radiation. After the second heating, they are quenched. After which they are again heated to a lower temperature and allowed to air cool. These furnaces are so designed and laid out that the axles are pushed mechanically through the first furnace and kept moving for a space of about 10 ft., until they reach a temperature within 50 deg. of room temperature. They are then mechanically fed into the second furnace, pushed through and quenched. A conveyor carries them from the quenching tank to the feeding mechanism of the third furnace, where they receive their final heating and are pushed out the rear end ready for the machine operations. It will be noted that the axles are handled mechanically throughout the process, and after being fed into the first furnace, do not stop until the three heat treating operations are complete. These three furnaces have a capacity of completely heating one front axle per minute. Although the heats are different in each furnace, the three furnaces are duplicates, with the exception of the draft and damper settings to bring about the required temperatures. We will describe more in detail one of these units.

The hearth is 5 ft. wide by 14 ft. long. The axles are placed on especially designed cast-iron ways with the forks hanging down. When the furnace is filled with these axles, the axles themselves form a practically solid floor which moves along through the furnace over the ways. Small pieces, such as camshafts, spiders, spindles, etc., are piled on top of the axles and are carried through the furnace, receiving exactly the same heat treatment as the axles. These small parts are handled by hand between each furnace, as no mechanism has, so far, been designed to handle them mechanically. The gas and air are delivered through the reversing valves to the regenerators at a pressure of approximately 3 in. of water. The four regenerators are placed directly under the hearth. The gas on the inside and the air on the outside. There is one combustion chamber immediately over each pair of regenerators and immediately under one-half of the hearth and extending under its entire length. The products of combustion pass through flues along the sides of the hearth, sweep over the hearth, down through the flues on the opposite side, divide after passing through the opposite combustion chamber, and down through the opposite pair of regenerators, through the reversing valves and out the stack. The furnace is reversed on an average of every 15 to 20 minutes. The products of combustion, while passing over the hearth, are directed by a series of jack arches placed every 2 ft. at right angles to the movement of material over the furnace hearth. A solid division wall, built from the foundation to the hearth, separates the two pairs of regenerators. The furnace is enclosed in a steel jacket with 2½ in. of insulating material between steel and brick work.

We might mention that we have built this type of furnace with a muffle to prevent the products of combustion from coming in contact with the steel, the idea of the muffle being to reduce the scaling to a minimum. After several months of comparative tests in running these furnaces with and without the muffle, we concluded that the benefits from the muffle did not warrant the additional expense in construction and operating cost. To maintain an average hearth temperature of 1650 deg., it was found necessary to keep an average temperature in the combustion chamber of 2550 deg. outside the muffle. The average gas consumption was 264 cu. ft. of gas per minute, the average cubic feet of gas per ton of stock being 22,970. The efficiency of the furnace was 14½ per cent.

With the same type of furnace, running under exactly the same temperature conditions and delivering the same amount of stock, without the muffle, that is, the products of combustion coming in contact with the steel, we find that the average gas consumption was 73 cu. ft. of gas per minute, or 11,500 cu. ft. of gas per ton of stock, with a furnace efficiency of 26 per cent, as compared with 14½ per cent, as stated above.

By furnace efficiency, we mean the total amount of heat put into the stock, divided by the total amount of heat delivered to the furnace in the gas.

From the above comparisons, it will be seen that the cost of operating, which will be discussed later, is very much greater when the muffle is used and the practical results on this kind of stock, with skillful operation, are about the same in both cases. We, therefore, conclude that for this type of work the muffle is not warranted. The muffle furnace, we feel, is not at all practicable unless double regeneration is used, as the heat losses would become enormous without efficient waste heat recovery. With double regeneration, however, it will be observed, even with the muffle furnace, a furnace efficiency is possible which is very much in excess of the ordinary oil-fired furnace, which rarely exceeds 10 per cent in efficiency.

We find that the temperature of the stock heated in the furnace can easily be kept within a variation of 10 or 15 deg. By skillful operation, there is no difficulty in keeping the temperature variation within 5

deg. These results have been obtained over tests of several months' duration.

It may be interesting to note that the Ford Motor Company is now adding six additional front axle heat-treating units of the Steere Company design, which will probably be in operation by the first of July.

At the time of writing this paper, we have not completed the work which has been going on for over two years, of developing a furnace to replace oil for drop forging work.

We now have about completed a double regenerative type forge furnace enclosed in a metal case, which will be thoroughly tested out within the next thirty days, but unfortunately, no data are yet available on this particular construction.

It might be interesting, however, to note the data which were taken on a forge furnace which we built and operated for several months on regular production. This furnace was of the recuperative type with metal recuperators. The hearth was 4 ft. wide by 2 ft. deep. The stock heated was 2-in. round bars. Parts weighing 3.88 lb. each were made from the heated bars in an upsetting machine.

One hour and 15 minutes were required to bring the temperature of the furnace from cold up to forging temperature. When the furnace was filled with stock, from 15 to 20 minutes were required to bring the stock to forging temperature. The furnace was run at a capacity of 318 lb. of stock per hour. The temperature of the stock varied from 1850 deg. to 1950 deg. Fahr. The temperature of the hearth varied from 2300 deg. to 2400 deg. Fahr. On an average, a differential of 500 deg. was maintained between the stock and the hearth temperature.

The average of several tests was found to give a fuel cost of $2.00 per ton of stock heated.

The furnace was operated by putting ten cold bars into the furnace at a time. This naturally lowered the temperature of the furnace, which, as stated above, required from 15 to 20 minutes to bring this stock up to forging temperature. After the stock had been brought up to furnace temperature there was a surplus of heat available and considerable care had to be exercised that the stock was not overheated.

It was found that better work could be done with this furnace than was done with the old furnace, because it was impossible to heat the stock too rapidly, that is, the core and outside of the bar were at practically the same temperature. Also the absence of smoke and dirt made the furnace much more desirable.

The above data were taken on one of the several forge furnaces of different types with which we have been experimenting. We feel that there is absolutely no question that producer gas can be successfully used on all forging operations.

ADVANTAGES OF REGENERATION VERSUS RECUPERATION

With properly designed regenerators, it is possible to recover a much higher percentage of the heat of the waste gases than is possible with recuperators, unless recuperators of very elaborate design are built. Recuperators may be built of metal or refractory material. The advantages of metal recuperators are in preventing leakages and short-circuiting. The disadvantages are in their very rapid deterioration, especially at higher temperatures. The disadvantages of regenerators, on the other hand, are that the regenerators must be reversed at intervals of approximately 20 minutes to half an hour, which requires additional mechanism and operating complications. The evidence which we have accumulated to date, however, is distinctly in favor of regeneration and against recuperation, as we have been unable to secure refractories which have the proper heat conductivity, and at the same time can be kept tight through the wide range of temperatures under which they have to operate.

We find that the expense of a furnace with the stock handled mechanically over the hearth, is not justified unless large quantities of stock of the same kind are to be heated. Also if the heating operations are run continuously for a good many hours, the extra expense of the mechanical furnace is not warranted.

Each particular problem, however, must be studied by itself, as it is impossible to lay down anything more than the most general rules. In a continuous mechanical furnace, such as the front-axle furnace above described, where one axle is charged and one discharged every minute, the front and rear doors must necessarily be open. This, of course, results in quite a loss of heat from the hearth. Intermittent furnaces, built with one door which can be kept closed during the heating operation, show higher fuel economy than furnaces open at both ends.

We have built furnaces similar in principle to the front-axle furnace described above, for use in annealing steel for stamping work where the material was maintained at 1650 deg. Fahr. The costs for this work were practically the same as for the 1650 deg. Fahr. heat treat on front axles, that is 40c. to 45c. per ton. This type of furnace has also been built for carbonizing gears.

We have also applied producer gas with entire success in brazing and for heating enameling ovens.

COST OF GAS

The cost of producer gas necessarily varies with the price of coal, water, labor, investment in plant, hours operated daily, etc. The labor and capital charge varies also with the size of the plant. For example, take a plant with a capacity of 3,000,000 cu. ft. of gas per 24 hours, with coal at $3.00 per ton, producer gas will cost 4¾c. per 1000 cu. ft. A plant with a capacity of 15,000,000 cu. ft. per 24 hours, and coal at $3.00 per ton, the gas would cost 4¼c. per 1000 cu. ft. On a B.t.u. basis, this corresponds to 4¾c. and 4¼c. oil, respectively. It must be kept distinctly in mind, however, that these figures are costs of the fuel delivered to the furnace and do not take into account capital charges of the distribution systems necessary, capital charges on the furnace investment, repair of furnaces, etc. In other words, it is the total cost of the fuel ready for distribution, rather than the cost of heating stock.

The following data are the result of continuous tests taken on the above described front-axle furnace from April 1 to April 20:

Output of furnace, tons per hour	0.781
Cubic feet of gas per hour	9,000
Cubic feet of gas per ton of stock	11,500
Calorific power of gas B.t.u. per cubic feet	127
Cost of fuel per ton of metal (gas at 3½ cents per M)	$0.401
Cubic feet of gas per minute for "furnace standing by"	73
Cost per hour for fuel for "furnace standing by" with gas at 3½ cents per M cubic feet	$0.154
Pounds of stock per hour per square foot of floor space	9.1
Per cent of total heat supplied furnace into stock that is, efficiency of furnace	26
Per cent of total heat supplied furnace to stack	8
Per cent of total heat supplied furnace to radiation	66

In the above test the fuel supplied the furnace was measured by means of a station meter. This meter measured the gas supplied to two furnaces, the gas being divided between the two furnaces by means of Pitot tubes installed on both furnaces.

The amount of heat that went into the stock was determined from the rise in temperature of the stock, and its specific heat. This specific heat was determined by laboratory experiment and found to be 0.12.

In the above data, special attention is called to the calorific power of the gas, which is only 127 B.t.u. per cubic foot. The reason for this low B.t.u. is that the gas was made by gasifying pea coke. This also accounts for the low cost of the gas per thousand cubic feet. This gas would be equivalent to ordinary producer gas at 4c. per thousand cubic feet.

This particular test has been selected out of a great many run to show that a very weak gas can be effectively used in a properly designed furnace, which is contrary to the general opinion that a weak gas cannot be effectively used. The results of these tests check very closely with the average of a long series of tests on gases of difficult calorific power.

Independently of ours, tests were run on the same furnace over an extended period, and at the same time tests were run on an oil-fired furnace to determine the comparative fuel costs of the two methods of heating. The results of these tests, which were made independently of our tests, showed that the cost of producer gas per ton of steel was 44½ cents, as against the cost of oil at $1.48, approximately 3 to 1 in favor of producer gas.

It should be noted again that this cost only applies to the cost of the fuel at the furnace.

We do not pretend to be able to give any costs of heating material with oil. We have run a good many tests and have the results of a great many tests, but there is such a tremendous variation that we prefer to use the figures on oil given us by our clients. We have found that in most cases the tests that were run to determine the costs of heating with oil are run over altogether too short a period. In the work we have done along this line, there have been enormous variations in the quantity used from hour to hour, which leads us to believe that the only way to arrive at a safe estimate is to run the test over a very long period. All of our producer gas data have been taken over a period of at least two weeks, and in most cases are run for two or three months.

In considering the substitution of producer gas for oil, some of the following points should be given most careful consideration. In general, producer gas is not to be considered on small installations. Local conditions and the future price of oil determine when a producer gas plant is or is not advisable. A producer gas plant should be run twenty-four hours a day to realize the best commercial results. It must be also borne in mind that the manufacturing of producer gas is a highly specialized industry in itself, and any concern figuring on adopting this fuel must accept the responsibility of running an entirely separate industry. Also it is difficult to obtain producer gas operators, as there are comparatively few plants running at the present time where men are trained in this kind of work. One of the solutions for this phase of the problem is to build central producer gas plants which will distribute gas to several concerns, having the producer gas plant a separate organization, selling gas to these various concerns the same as the ordinary city gas plant distributes gas.

Plant managers and superintendents must also keep in mind that a radical substitution of fuels must necessarily change their operations to some extent. We have found that it is at first quite difficult to get men who have been accustomed to using oil to change to producer gas, especially if they are working on piece work. After becoming accustomed to gas, however, they prefer it. As has been pointed out above, radical furnace changes are also necessary if the best results from producer gas are to be obtained. In this connection it may be interesting to note that we have in several cases changed over existing oil furnaces to producer gas furnaces with entirely satisfactory results as far as heating was concerned. The cost of the gas, however, was necessarily high because of the inefficient use of the gas. The results to date on this kind of work have indicated that the ordinary oil furnace, with a very small expense, can be converted to a producer gas furnace and operated at a cost corresponding to about 6 cents to 7 cents oil.

Briefly, the advantages of producer gas may be summed up as follows:

It furnishes a dependable fuel supply under your own control—that is, it is as dependable as coal.

It can be used for all classes of heating work, including enameling.

The flame temperature being low and the gas volume large, there are no intensely hot spots in the furnace, with the result that repairs on brick work are next to nothing.

The highest furnace efficiencies are possible with gas.

In every application that we have studied we have found that the costs were less with producer gas than with oil.

More uniform heating of the stock, and more accurate control of temperatures were possible.

Last, but not least, every gallon of oil that automobile men use in making cars leaves that much less oil for making gasoline to run them with. Automobile manufacturers, above all manufacturers, should discourage the use of oil for everything outside of making gasoline. The present high price of gasoline, as well as the high price of fuel oil, can be traced back in large part to the tremendous quantities of crude oil that are consumed by manufacturers of automobiles and their accessories.

In conclusion, we call your attention to the fact that practically all of the work which we have done to date has been done while production was in full swing. A great number of practical problems have presented themselves, which it was necessary to overcome in order that production would not cease while the experimental work was in progress.

Also it must be kept in mind that the application of clean producer gas to industrial heating operations may be considered as an infant industry. From our observations to date, however, we feel that the infant is rapidly growing and that the future of this fuel is assured.

Course in Laboratory Organization.—A course on Laboratory Organization and Management is offered in connection with the summer session at Columbia University by Prof. Thomas B. Freas and Prof. W. L. Estabrooke. This course is unique in character and content. It is planned to take the students' full time for six weeks. The subjects carried will be: location, laboratory construction, ventilation, etc., of buildings; laboratory equipment, including desks, lockers, shops, gas, electricity, water, suction, liquid and compressed air, balances, etc.; buying from foreign and domestic markets, economic and scientific handling of supplies; organization of stockroom employees and their cooperation with the teaching staff; glass blowing by a professional glass blower will be a special feature; a series of trips in and about New York to manufacturing establishments, industrial and university laboratories, including trips to Boston, Washington, D. C., Niagara Falls, Buffalo, Rochester, Syracuse and Philadelphia, in which there will be opportunity to observe actual application of chemistry to needs of the country from the most modern viewpoint; and especially to the needs of university, college and industrial research laboratories in order to meet the demands of modern chemistry.

Recent Developments in the By-Product Coking Industry of Japan

By T. Kurahashi

In Japan, especially at Kyushu, Osaka, and Tokyo, there are many coke plants, but most are beehive ovens. There are by-product ovens, however, at the following places:

1. Tokyo Gas Light Company, Ltd., Tokyo.
2. Osaka Seimi Company, Ltd., Osaka.
3. Mitsubishi Makiyama Coke Plant, Tobata, Fukuoke.
4. Imperial Steel Works, Yawata, Fukuoka.
5. Miike Colliery, Omuta, Fukuoka.

Of these the Imperial Steel Works and the Miike Colliery are most important.

The Tokyo Gas Light Company, the oldest and biggest gas company in Japan, has several gas works around the metropolis, namely, Semju, Fukagawa, Oshima, Shiba, Sunamura, Omori, and the Fukagawa tar products works. Of the gas works, the first four are operated with retorts, while the last two, Sunamura and Omori, have by-product ovens. The Sunamura plant has two batteries, one of 18 Koppers regenerative ovens, the other of 15 of the Semet-Solvay type. The Omori plant has one battery composed of 10 Koppers recuperative ovens. Both works recover by-products—tar, ammonium sulphate, and also benzol from the Semet-Solvay ovens. From the Koppers plants, the surplus gas is used for illuminating purposes so that the benzol cannot be recovered, because it is an important illuminating component in the gas. On the other hand, tar and other by-products in the crude state are shipped in small tank boats to the Fukagawa Tar Product Works, and treated so as to produce various dyestuffs, medicines, and other high-grade coal-tar distillation products. The coke is sold for foundries and metallurgical plants, and the breeze for fuel for limekilns.

The Osaka Seimi Company, Ltd., Osaka City, is one of the oldest coke by-product recovery plants in the Japanese Empire, and its former chief engineer, Dr. K. Shimomura, who is the foremost authority on the coke industry in Japan, contracted with the Semet-Solvay Company about twenty years ago, to build one battery of 10 Solvay-type ovens, thus founding the first by-product coke oven plant in Japan.

Now the company has two batteries of the same type, with tar, ammonium, sulphate, naphthalene and benzol recovery plants and dyestuff factory. But last year the dyestuff factory was transferred to the Japanese Dyestuff Manufacturing Company, Ltd., with the similar plant of the Osaka Gas Light Company, Ltd., and hereafter Dr. Shimomura will be the chief engineer of the new company.

The northeastern Kyushu, famous as a coal field and on account of its recent industrial growth, is important for the coke industry. It contains three by-product coking plants as follows:

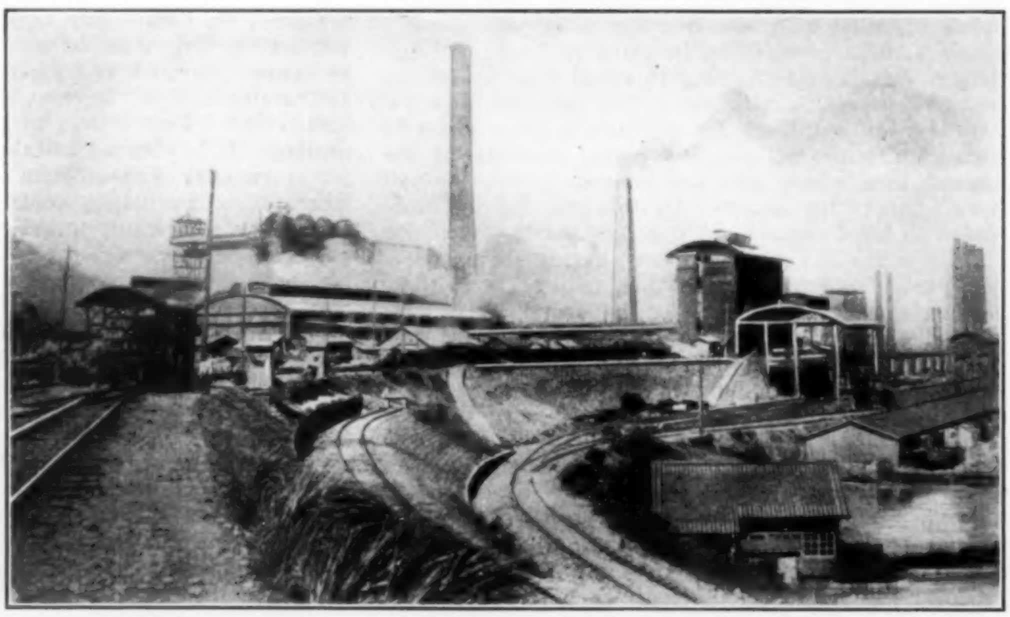
The Mitsubishi Makiyama Coke Mfg. Company was established in 1910, to supply the blast furnace coke to the Imperial Steel Works, and it was originally operated with beehive ovens. But now it has two batteries of Semet-Solvay by-product ovens, one of 25 ovens, the other of 10 ovens, besides 50 beehive ovens. Tar, crude naphthalene, and benzol are recovered.

One of the interesting features of the plant is that ammonia liquor and surplus gas are supplied to the Asahi Glass Mfg. Company, Ltd., the biggest and only window glass factory with the American mechanical blowing system in Japan, and there the surplus gas is used as fuel in the glass making. Ammonia liquor is also furnished to the Am-Solvay Process Soda Manufacturing plant, which belongs to the glass company.

The Imperial Steel Works, the most distinguished steel and iron works in the Orient, have coke plants for the blast furnaces. They were formerly beehive ovens of the Coppee type, but are now by-product ovens of the Semet-Solvay and Koppers types. The Semet-Solvay plant comprising 150 ovens, arranged in six batteries of 25 each, each oven having a capacity of 6 to 7 tons of coal, had been built up in 1907-8; on the other hand, the Koppers type, comprising one battery of 120 ovens, each of 7 tons capacity, were begun in 1914. Tar, ammonium sulphate, naphthalene, and benzol recovery plants are in operation, and the benzol is supplied to the Japanese Dyestuff Manufacturing Company.

In this connection, I will mention the results obtained in experiments on the utilization of coke-oven waste heat for steam raising with the Babcock & Wilcox multitubular boilers by the engineers of the Steel Works. The waste heat from one battery of the Semet-Solvay ovens which carbonize 100 tons of coal per day, can raise 45.6 tons of 8 atmospheric pressure steam per day, that is, 456 kg. per ton of coal per day; on the other hand, the surplus gas from the ovens can raise 580.8 kg. of steam per ton of coal carbonized, thus we have a total of 1036.8 tons of steam per battery per day. The steam, of course, is used for steam engines in the central power station of the works.

It is said that the Steel Works had decided to contract for any new type of coke oven of recent enlargement, and it will apparently contract with some American by-product coke oven builder as yet undecided.



WHOLE VIEW OF COKE PLANT, IMPERIAL STEEL WORKS, YAWATA, FUKUOKA

The Miike Colliery, the largest colliery in Japan, which belongs to the Mitsui Mining Company, Ltd., Tokyo, has the most improved 122 Koppers regenerative ovens in four batteries (in which is No. 4 battery just put in operation), each oven of 8 tons capacity; the coal carbonized amounts to about 120 tons per battery per day. Plants for the recovery of tar, ammonium sulphate (Koppers direct process), naphthalene, anthracene, and benzol, and also for the manufacture of dyestuffs are provided. Of these, alizarine dyestuffs produced from the anthracene are the only ones successfully made in Japan. The gas produced amounted in 1916 to 3,600,000 cu. ft. per day (from three batteries) of which 1,800,000 cu. ft. were used for the coking, 1,200,000 cu. ft. for the two gas engines, each of 3,000 hp. (one is spare), the surplus for boilers, zinc furnaces, etc., and finally a part for delivery to the city for the use of the Omuta Gas Light Company, Ltd.

According to news which I received a few days ago from Tokyo, it would seem to be a fact that the works are engaged in research on a type of new coke plant that will be built in parallel with the present Koppers ovens, and that the works will select some new type, now being improved in the United States of America.

The South Manchurian Railway Company, Ltd., has decided to adopt the Roberts type of oven for the coke plant which will belong to the An Shan Chan Steel Works in South Manchuria, and the company has contracted with the American Coal and By-product Coke Company of Chicago, Ill., about the new coke and its by-product plants. The annual output of coke is said to be about 150,000 net tons.

The coal used in present practice in the works mentioned above is as follows:

	Ash	Vol. Mat.	Fixed Carbon	Sulphur	Locality
Bujun	7.53	50.36	42.11	0.71	Manchuria
Miike	14.85	40.23	44.92	3.92	Kyushu
Takashima ...	8.58	37.15	54.27	0.95	Kyushu
Honkeiko	20.54	21.52	57.94	0.143	Manchuria
Kaihei	14.70	31.70	53.60	1.183	Manchuria
Amakusa	10.92	17.20	71.88	0.976	Kyushu

Among them, "Takashima" produces good coke, low in ash and sulphur, high in calorific power and moderate in coking power, but a little high in phosphorus.

"Miike" is famous too, of high calorific power, moderate caking power, rich in by-products, but one defect is its high sulphur content.

"Honkeiko," low in sulphur, phosphorus, and volatile materials, produces good coke, but it is unsuitable for use in the blast furnace because of its high percentage of ash and also its high melting point. "Kaihei," "Sakito," "Futase," "Amakusa," are good too.

With respect to the by-product coke industry, there is a great question as to the future of the dyestuff manufacture in Japan. The importations of dyestuffs into Japan, almost all of them from Germany, were as follows (1 yen = $0.50):

	Synthetic Indigo	Other Coal-tar Dyes
1913..................	Yen 1,879,967	4,154,658
1914..................	3,277,362	4,485,691
1915..................	....	....
1916..................	123	2,385,526

This shows that the annual importations amounted to about 7 or 8 million yens, that is nearly 3.5 or 4 million dollars. But since the beginning of the great war, importations have been cut off, and the shortage of the stock has brought about an unnatural rise in their prices. Under these circumstances, many consumers have turned their attention to the possibilities of home supply.

Japan has 40 color works now, but many of them being on a very small scale are unsuitable for that kind of industry. The few which follow are the exception:

1. Tokyo Gas Light Company, Ltd., Tokyo.
2. Japanese Dyestuff Manufacturing Company, Ltd., Osaka.
3. Yura Dyestuff Manufacturing Company, Ltd., Wakayama.
4. Miike Colliery Omuta, Fukuoka.

In my opinion, it would be better for Japan to have one or two large works (say one in Osaka and the other in Kyushu) instead of forty or more little works. When peace comes, I am afraid that the small works will suffer and many of them be forced to stop operation, but the excited Japanese manufacturers will not heed my advice, and I fear that time will prove the correctness of my opinion.*

*The author of this article is at present in this country and will be glad to answer inquiries concerning the above subject or other chemical and metallurgical industries in Japan. His address is care of Japanese Consul General, New York City.

Potash from Cement at the Riverside Portland Cement Company

In our June 1 issue, page 653, we gave a short description of the work being carried on in the recovery of potash at the plant of the Riverside Portland Cement Company, Riverside, Cal. We are indebted to Mr. John Treanor, manager of the company for the following additional data.

GENERAL CONSIDERATIONS

This company is now recovering 6 lb. of potassium sulphate for every barrel of clinker burned. This quantity at present price is worth from 40 to 50 cents per barrel of cement produced. On the pre-war basis the same material would have a value of about 18 cents

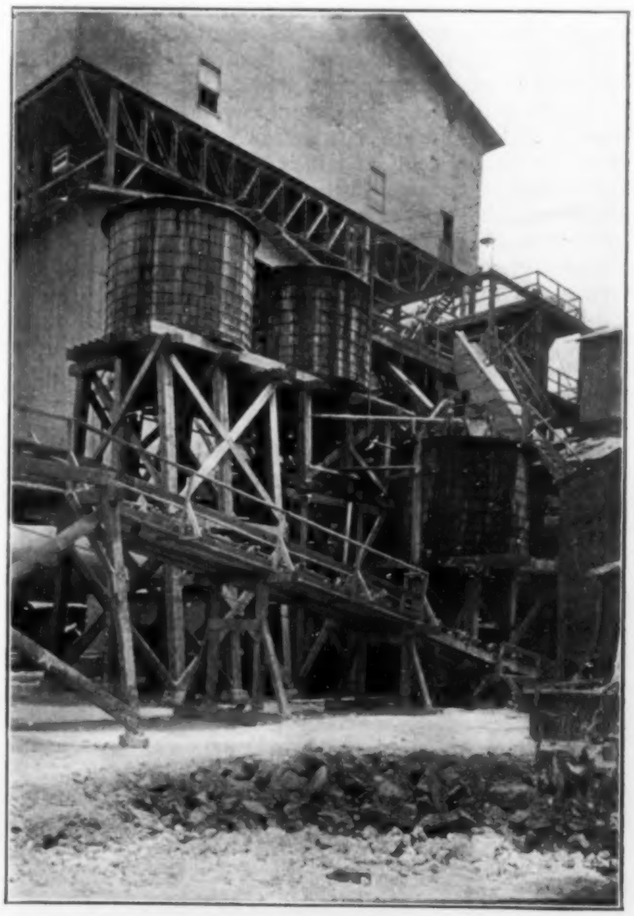


FIG. 1—HOT WATER AND MIXING TANKS AND BELT DISPOSING OF FILTER CAKE

per barrel, a figure which would still leave a very attractive net profit.

Clays and shale suitable for Portland cement manufacture vary in K_2O content up to values as high as 2½ per cent. During the past year many Portland cement raw mixtures from Eastern manufacturers which were examined in the Riverside laboratories were found to contain from 0.8 to 1.25 per cent of K_2O.

In the ordinary burning of Portland cement raw mix, from 40 to 50 per cent of the potash content is volatilized and leaves the kiln with the kiln dust. This volatilized potash can be recovered in the form of a more or less dilute salt by the installation of suitable dust collecting systems.

The amount of potash recovered depends upon the efficiency of the collecting devices. The efficiency of the Cottrell electrical precipitators varies from kiln to kiln; the best individual kilns giving results as high as 80 per cent of the potash volatilized, while individual treaters over other kilns have an efficiency as low as 55 per cent. A 100-ft. rotary kiln, for example, may produce anywhere from 4 to 7 tons of dust daily, whose average potash content may range between 4 and 10 per cent. The Western Precipitation Company worked out the problems of electrostatic precipitation.

The potash contained in this dust is usually water soluble, or if part is insoluble it will be amenable to further chemical treatment. This potash containing dust recovered from the kiln gases can be sold as dilute fertilizer just as it is. Such a by-product is regularly being produced by the Security Portland Cement Company at Hagerstown, Md., and by the Alpha Portland Cement Company at its plant on the Hudson River.

The use of this dust, however, is restricted to agricultural operations requiring a lime base fertilizer. It cannot be conveniently used as an ingredient for a complete fertilizer on account of its dilute form. The cost of freight upon 90 per cent of inert material is burdensome, reduces the net selling price, and limits the available market. The usual requirement for complete fertilization work is a salt whose K_2O content is not under 35 per cent, and it is toward this ideal that efforts have been directed in striving for a process for recovering potash from cement plants.

The potash recoverable from all cement kilns under all conditions will be in the form of potassium sulphate. During the past five years the laboratories at Riverside have been working on the problem of deriving a more concentrated salt from this dust. One of the obstacles, however, was that only 50 to 55 per cent of the total K_2O originally present in the dust could be extracted in water soluble form.

Recently it has been discovered that the cause of this poor extraction was the formation of a double salt of potassium and calcium sulphate which at ordinary temperatures has a low degree of solubility. This double salt is the mineral sygenite, occurring in nature. Knowing the cause of the poor extraction it was but a step further to remedy it, and it was finally found that by keeping the mixture at a minimum temperature of 85 deg. C. during the leaching and filtering process, and maintaining proper conditions of concentration, all of the water soluble potash originally present in the dust could be recovered. A patent (No. 1,220,989) based upon this simple fact has been obtained.

CALCIUM FLUORIDE PROCESS

For every 1 per cent of K_2O in the raw mixture it would be theoretically possible with this process to recover 6 lb. of K_2O from each barrel of clinker, providing the volatilization is complete. Upon the pre-war basis of 3 cents per pound, this would amount to 18 cents per barrel, so that any economical means by which a better volatilization of K_2O from the clinker could be accomplished would be decidedly worth while. Working toward this end a process was developed (patent No. 1,194,344) which makes use of calcium fluoride as a reagent for increasing the volatilization of potassium salts from the clinker and the regeneration of the reagent from the dust collected. This is accomplished as follows:

For every 1 per cent of K_2O present in the raw mix, approximately 0.8 per cent of calcium fluoride is added. This addition permits the formation of potassium fluoride, which is readily volatile and has a boiling point of about 850 deg. C. The reaction between the calcium fluoride and the potash in the raw mix, however, does not take place until a temperature of about 1100 deg. C. is reached. At this temperature, which is far in excess of its boiling point, the salt will be rapidly expelled from the raw mixture and carried off with the gases of combustion and the dust.

This volatilized potassium fluoride, however, does not persist in this form. It is more or less completely converted by the oxides of sulphur in the gases of combustion to potassium sulphate. This transformation is accompanied by the liberation of hydrofluoric acid, which is immediately neutralized by the lime compounds in the dust and is converted into calcium fluoride. This dust is then leached by the process already described and the soluble potassium sulphate separated from the insoluble calcareous and argillaceous material by filtration.

The filter cake obtained by this operation is a useful raw mix containing in addition to cement making substances all of the calcium fluoride originally used, and

FIG. 2—EVAPORATING PONDS, AND POTASH PLANT

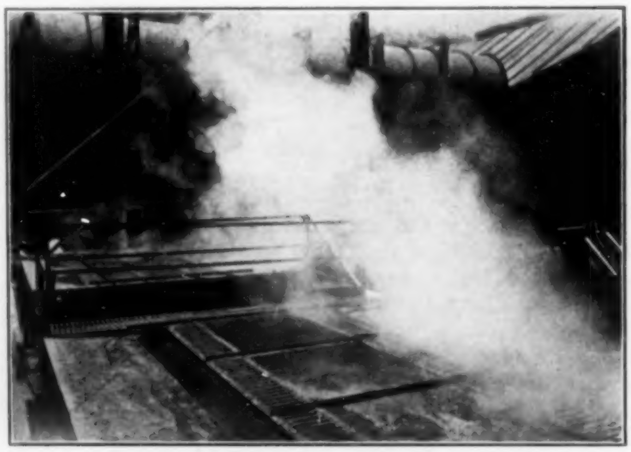


FIG. 3—EVAPORATING PANS, "COOKERS"

in addition to this the deleterious constituent, lime sulphate.

Originally it was attempted to enrich the dust by reburning it, and although this gave a very rich potash dust, the operation was extremely uneconomical. In fact, only 20 per cent of the total potash fed into the kiln in the shape of stack dust and treater dust was volatilized. The remainder, or 80 per cent, was driven into the clinker.

The cause of this was found to be the calcium sulphate present in the dust. In the presence of fluoride, however, the calcium sulphate decomposes, which discovery was embodied in patent No. 1,219,315. This reaction then makes it possible to again return the filter cake containing among other things the calcium fluoride to the raw mix where the calcium fluoride again performs its function of increasing the volatilization of the potash in the raw mix. By this cyclic process the volatilization at the Riverside plant was increased from 60 to 90 per cent.

Summing up the possibilities of recovery of potash as a by-product in Portland cement manufacture, the experience at the Riverside plant indicates that 90 per cent of the potash contained in the raw mix can be volatilized; 10 per cent remaining in the clinker. Eighty per cent of the potash so volatilized in the kiln should be caught by the dust collectors. The net product, about 70 per cent of the original input, will be still further reduced about 5 per cent by losses in filtering. It has been demonstrated by the work at Riverside that it is entirely conservative to look for the recovery, in the form of concentrated salt, of 66 2/3 per cent of the potash originally contained in the raw cement mix, and it is quite possible that even these results may be improved upon by increase in the efficiency of the dust collectors. The resultant salt is received most enthusiastically by the fertilizer trade.

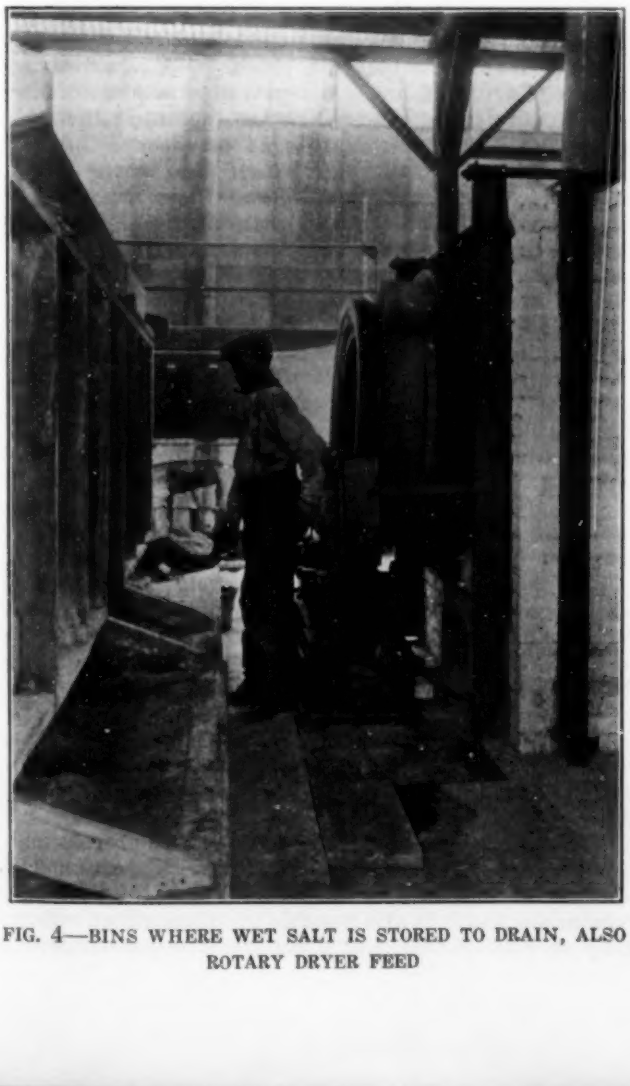


FIG. 4—BINS WHERE WET SALT IS STORED TO DRAIN, ALSO ROTARY DRYER FEED

MECHANICAL FEATURES OF THE PROCESS

The dust is drawn from bins under the electrical treaters into tanks where it is put into solution by agitation in water of not less than 85 deg. C. at a concentration of not over 5 per cent K_2O. The apparatus consists merely of cylindrical tanks some 12 ft. in diameter and 8 ft. high, which have on their axis a vertical shaft carrying ordinary propellers. The tanks are filled with water to a depth of about 6 ft. and the water brought up to the desired temperature by means of steam injected into it. Fig. 1 shows two hot-water storage tanks on the left and one of the agitator or mixing tanks on the right. There are three of these mixing tanks, each delivering a batch every fifty minutes. The dust is then charged into this heated water and the temperature rapidly rises to boiling point, due to the hydration of the lime contained in the dust. Samples are taken every few minutes, filtered, and specific gravity determined as well as percentage of solids. The potash goes into solution surprisingly fast under the conditions described. The whole operation of extracting the water soluble potash from 7 tons of dust is accomplished in less than fifty minutes, and the whole control has reduced itself to a very simple basis.

As soon as a batch is cooked in one of the tanks it is run by gravity into the filter reservoir under an Oliver filter press, where its temperature is maintained by steam coils, and the whole is kept at a homogeneous consistency by means of an agitator. The suction of the filter drum then forms a cake, and as the drum revolves this cake emerges from the pulp and encounters a bank of hot water sprays. Suction is applied automatically after passing this point to remove as much water as possible from the cake, which, when it reaches the horizontal position of the floor level, is scraped off by means of a plow.

The solution thus extracted from the cake is passed directly to storage tanks (Fig. 2), which are at the same time settling and evaporating ponds by means of solar evaporation, which is very active in the dry climate of southern California. When the liquid has attained a specific gravity of about 1.1 per cent it is pumped to the evaporating pans (Fig. 3), where the liquid level is maintained at a fixed point and the solution becomes more and more concentrated and the salt drops to the bottom. The company has five of these pans installed. It is then raked out upon a drain board, where it is allowed to remain some minutes, and thence is deposited in a hopper, where draining continues for several hours (Fig. 4). From this hopper it is passed through a rotary dryer, thence through a William's mill, where it is reduced to the desired fineness, and finally the salt proceeds to a bin under the sacking machine.

Credit for the invention of the chemical processes employed belongs to Frederick W. Huber, chief chemist of the Riverside plant, and to his assistant, Frank F. Reath.

Manufacture of Calcium Carbide in Brazil.—According to the annual report of the Companhia Brazileira Carbureto de Calcio, established in the city of Palmyra, State of Minas Geraes, the production of calcium carbide by this company during the year 1916 was 61,016 drums, as against 50,146 for the previous year. The board of managers calls attention to the fact that not only is the product well received in Brazil, but that considerable quantities have also been exported to the Argentine Republic.

Synopsis of Recent Metallurgical and Chemical Literature

Switchboard for Experimental Work.—A description of a cheaply constructed laboratory switchboard, especially arranged to give great current flexibility, was given in a paper by W. L. Badger at the recent Detroit meeting of the American Electrochemical Society. The board was built in the shops at the University of Michigan in 1915 and is used by the Chemical Engineering Department. It is stated to have cost a little over three hundred dollars. The transformer is rated at 10 kva. and is built for 230 volts on the high-tension side. The high-tension winding has five taps, so that low-tension voltages of 10 per cent above nominal, 5 per cent above nominal, nominal, 5 per cent below and 10 per cent below, may be obtained. On the low-tension side are two 10-volt coils and two 20-volt coils. The transformer was obtained from the Enterprise Electric Co., Warren, Ohio. A diagrammatic sketch of the wiring is shown in Fig. 1. The supply line is connected to a double-pole circuit breaker shown at the top of the board. This is provided with both overload and shunt release coils. From the breaker the current passes to the double-pole double-throw switch *I*, which connects the 220 volts either to the busbars direct, or to the high-tension side of the transformer through the three single-pole double-throw switches *E*, *F* and *G*. The five taps of the high-tension winding are connected to these as shown by the numerals. By suitable combinations of series, parallel or series-parallel connections, low-tension voltages, can be obtained of 60, 50, 40, 30, 20 or 10 volts at ratings of 100, 83, 67, 100, 100 and 33 per cent respectively. With any one of these arrangements the voltage may be varied through five smaller steps by means of the switches *E*, *F*, and *G*, as shown above. The result is a very flexible arrangement, particularly suitable for granular carbon resistance furnaces where there is a wide range of resistance, as temperature changes. From the low-tension connections the current passes through the ammeter transformer and then to the furnace-room busbars.

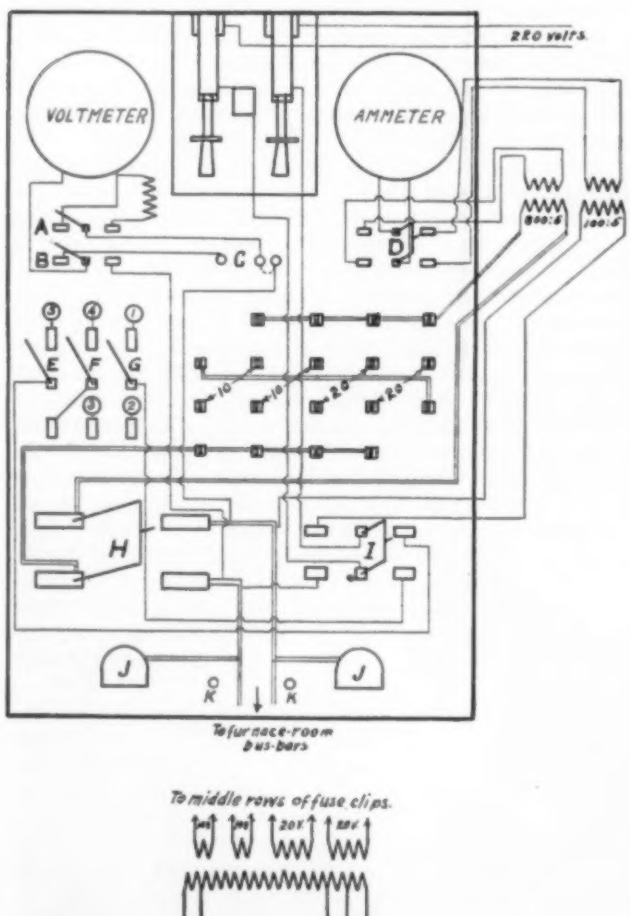


FIG. 1—TRANSFORMER BOARD FOR ELECTRIC FURNACES

Potash from Feldspar.—In the Canadian Chemical Journal, Vol. 1, No. 1, May, 1917, D. J. Benham, secretary of the National Potash Corporation of Toronto, describes a process used by this company in extracting potash from feldspar. The process was worked out by Allan Grauel of Kitchener, Ont., who was financially interested in a powder plant at the beginning of the war. The impossibility of securing the necessary potash for their operations induced him to devote his attention to the problem. The process, which is protected, consists in heating to a high temperature in a blast furnace, 110 tons of a mixture of feldspar, coal, calcium chloride and limestone. The limestone is used to render the slag fluid, while the chlorine of the calcium chloride combines with the potash, forming potassium chloride which distills over at the temperature of the blast furnace into a condenser where it meets a current of steam, in which it dissolves. By a process of evaporation and crystallization of the solution thus obtained, the salt is obtained in a high state of purity. It has been exhaustively tested out in the plant of the National Portland Cement Company, Ltd., at Durham, Ont. The success of the process is stated by the author to be in a large measure due to the earnest co-operation and assistance rendered by Mr. William Calder, formerly president and general manager of the plant at Durham, who unsparingly placed his extensive, modern equipment as well as his personal resources at the disposal of Mr. Grauel for the concluding experiments under commercial conditions.

It was found possible, with proper preparation of the charge, to drive off, under the most favorable conditions, over 90 per cent of the total potash content in the feldspar, which ranges from 8 to 14 per cent K_2O. The present percentage of collection of the vapors is not entirely satisfactory, however, and improvements are under way on this feature of the process. A satisfactory process for disposition of the soda vapors from the potash has also been developed. The mother liquor containing the potassium salts after being drawn off from the gas condensing and filtrating equipment is subjected to centrifugal treatment and evaporation. An evaporating pan, 12 x 60 ft. by 1 ft. deep being utilized. The gas treating equipment consists of a coil through which the volatilization products are collected and precipitated with steam. For the present only muriate of potash will be produced but satisfactory experiments have been conducted in the manufacture of caustic potash. It is of course also comparatively easy to produce chlorate from the chloride, but the entire manufacturing attention of the National Potash Corporation, Ltd., the company which has been organized to operate under Mr. Grauel's patents, will be concentrated on the production of muriate, which is so urgently required in the manufacture of explosives and for fertilizers for the great wheat, corn and cotton belts. Within a short time, however, the equipment for manufacturing caustic will be installed. The company expects to have its first unit with a capacity of 20 tons a day in active operation by the first of June.

It is stated to be possible to so adapt the process and the equipment as to utilize cement marl as a raw material instead of feldspar, where the latter is not readily obtainable, and it is also possible to utilize either rotary kilns or blast furnaces of a certain type for releasing

the potassium fumes. In operating the blast furnace the slag is converted into sewer pipe, tile and paving brick, being poured direct from the furnace into the molds. It has a peculiar porcelain-like surface like all feldspar products. An interesting statement made in the article is as follows: "By their aid (the feldspar fields), the Canadian company will assuredly be able not only to break effectively the world-wide monopoly of Germany in potash production, but it should be able to capture and hold securely the whole American market if it treats the consumer fairly." There is, however, a peculiar feature connected with the burning of feldspar, for which no reason is yet revealed. This is the fact that all of the potash content does not volatize at the same degree of temperature. A certain percentage is released at say 900 deg. C., more at 1000 deg, and so on until the last of it is finally driven off at about 1600 deg. This feature has presented grave difficulties.

Ferromanganese.—In the Journal of the Franklin Institute for May, 1917, ROBERT J. ANDERSON gives a review of the ferromanganese situation since the outbreak of the war. He points out that prior to the war we were the only steel producing country which did not produce its requirements of ferromanganese. Our steel manufacturers were obtaining cheap supplies from England and Germany and prior to 1914 the only company in this country manufacturing ferromanganese was the United States Steel Corporation. Since the war started, however, the manufacture of ferromanganese and spiegeleisen has been actively taken up and in 1916 we not only produced 75 per cent of our requirements, but both ferromanganese and spiegeleisen were exported to Canada, Italy, Sweden, Holland, Australia, etc. Most of the manganese ore for this production came from Brazil. Russia and India were formerly large exporters to other countries but these sources of supply were cut off and we have had to depend on Brazil for our manganese ore for making ferromanganese. Prices for ferromanganese in 1916 reached unheard of levels and the development of substitutes would be most acceptable to the steel producers. The author sums up his article as follows:

"It appears, in the light of the facts presented in the foregoing, that the manganese situation is one of serious importance—one that warrants thoughtful consideration on the part of those interested in the subject. The possibility of metallurgical science discovering a substitute deoxidizer which will take the place of manganese, either in whole or in part, appears to be an alluring one. Naturally any attempt at such an endeavor will call for a large amount of labor on the part of many men, and it is not to be supposed that the final solution of the problem will be effected in any short time. The matter of obtaining suitable co-operation with steel makers for the use of their plants so that experiments may be carried out on a scale commensurate with that of practice is one that will have to be taken care of by research men who hope to contribute in large measure to any progress along this line. Steel works laboratories have an opportunity before them if they have not already grasped it—and they apparently have not, if published data can be any criterion. A recent investigation carried out in this country by H. M. Boylston [Carnegie Scholarship Memoirs of the Iron and Steel Inst., Vol. 7, p. 102 (1916)], appears to be the first well-defined attempt in this direction."

Pyrometers.—Before a recent meeting of the Steel Treating Research Club of Detroit, Mich., RICHARD P. BROWN, president of the Brown Instrument Co., of Philadelphia, Pa., presented a paper on "Pyrometers—Past, Present and Future." Mr. Brown gave a history of the development of temperature measuring devices, and pointed out along what lines development in the future may be looked for. He discussed air, gas, water, optical, radiation, resistance and thermo-electric pyrometers. The thermo-electric method is the one in greatest use and he took up a discussion of the millivoltmeter and potentiometer methods of thermo-electric pyrometry. He said "the advantage of the potentiometer method of measuring temperature, is in its extreme precision, and its independence of resistance changes throughout the thermo-couple circuit. It has the disadvantage as compared with the millivoltmeter method that it is not direct reading, and that some outside source of current, a dry cell, for example, is necessary as a source of current to oppose the thermocouple, and this cell must be replaced frequently."

In discussing the future for pyrometry, he said "it would seem that the greatest development work in temperature measuring instruments will be done with the perfection of optical pyrometers, resistance thermometers and thermo-electric pyrometers. There is a field for a high grade optical pyrometer which can be used by any number of operators, who will all secure the same results from the instrument. Resistance thermometry will for some time continue to be limited to use at low temperatures unless some suitable metal is found for use in place of nickel to form the bulbs. In thermo-electric pyrometry it is possible to develop better materials than those found to date for base metal thermo-couples. The insulation or protecting tube will be difficult to improve upon. With the direct reading millivoltmeter doubtless the resistance of these instruments will be greatly increased, and I know that we have spent an endless amount of development work the last year or two along this line, and other pyrometer manufacturers are doubtless doing the same thing. The more the internal resistance of the pyrometer can be increased, and at the same time maintain the robustness of the construction, the better the instrument. With the potentiometer method of temperature measurement, doubtless development work can be carried on to advantage in producing an indicating instrument which will be direct reading throughout the scale range, and which will be simplified and less delicate than the types available at the present time. I think, however, the greatest future in pyrometry is along the line of automatic temperature control. I have with me here an instrument which automatically controls the temperature of an electric furnace. By means of solenoid operated switches the circuit is opened and closed through the rheostat, maintaining the temperature constant within 10 deg. Fahr. We have one of these automatic temperature control instruments in use on a japanning oven at the Willys-Overland Co., in Toledo, and nineteen more under manufacture for them. These instruments automatically maintain the temperature constant in an electrically heated oven, and this same type of instrument can just as easily be used on electric heat treating furnaces. We are experimenting with an instrument at present on an American Gas Furnace to operate gas valves, and control the temperature automatically, and while this instrument is in satisfactory operation in our own plant, it is not developed to a point where it is ready for general use. In closing, I wish to also suggest that the various steel manufacturers, and men like yourselves, who are interested in the improvement of heat treating methods, can be of great assistance to pyrometer manufacturers in co-operating with them to test out new devices in an endeavor to improve on present methods. We have made great strides in this country in the past few years in improved methods of heat treatment, and co-operation on the part of all concerned will mean very much greater strides in the next few years."

Recent Metallurgical and Chemical Patents

Sintering

Sintering Fine Ores.—A continuous sintering machine, especially designed for sintering iron oxide ores is patented by HEINRICH BITTMANN, of Frankfort-on-the-Main, Germany. The patent is assigned to the Dwight & Lloyd Sintering Company, of New York City. A longitudinal section of the apparatus is shown in Fig. 1 and a cross-section in Fig. 2. A layer of fuel is fed

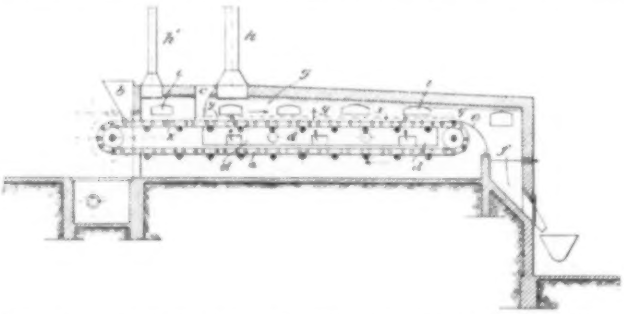


FIG. 1—LONGITUDINAL SECTION OF SINTERING MACHINE

onto the revolving grate *a*, from hopper *b*, and onto the fuel layer is fed a thin layer of ore, or ore mixed with fuel, from hopper *c*. The fuel is brought to ignition between the feed hoppers *b* and *c* by pressure or suction blast. An air box *d* is arranged below the charge support and air is supplied to this box, and passes upward through the grate, fuel and ore. The sintered material is delivered from the grate at the end

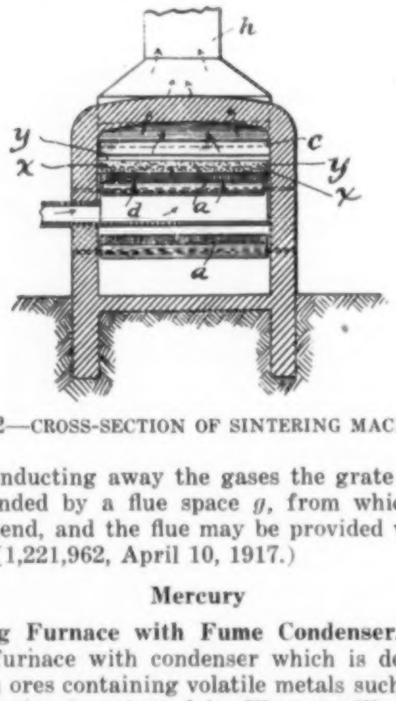


FIG. 2—CROSS-SECTION OF SINTERING MACHINE

e. For conducting away the gases the grate base may be surrounded by a flue space *g*, from which flues *h* and *h'* extend, and the flue may be provided with manholes *i*. (1,221,962, April 10, 1917.)

Mercury

Roasting Furnace with Fume Condenser.—An ore roasting furnace with condenser which is designed to operate on ores containing volatile metals such as quicksilver and zinc is patented by WILLIAM W. WHITTON, of Oakland, Cal. A cross section of the apparatus is shown in Fig. 3, in which *A* indicates in general a furnace constructed of brick and suitably lined to resist high temperatures; 2 the fire-box and 3 a main heating chamber which is provided with retort tubes generally indicated at *B*. Extending across the main chamber 3 are superposed frames 4, which are provided for the purpose of uniformly distributing the heat from the fire-box about the retort tubes before escaping through the flue indicated at 5, which may be connected with a stack not here shown. Each frame 4 consists of an iron grating, provided with staggered rectangular shaped openings. These openings are provided for the purpose of permitting the insertion of the individual retort tubes and also to permit the same to be readily removed. The furnace gases travel in the direction indicated by the arrows. Extending through each retort tube is a perforated pipe 17. Mounted below the bottom frame 20 is a plate 21 and mounted below said plate is an inclosed tank 22, which is partly filled with water. The lower ends of the individual perforated pipes 17 are connected with the upper end of this tank and the tank is in turn connected through a pipe 23 with a suitable form of condenser 50 and a suction blower 51. Mounted on top of the furnace A is an ore-bin 24, the bottom of which is formed by the frame 12 and the open ended retort tubes *B*. The ore delivered to the bin 24 is permitted to fill the individual retort tubes and the ore thus delivered to the individual tubes is prevented from freely discharging through the lower ends by the plate 21. The mercury or other volatile products from the ore are drawn off through

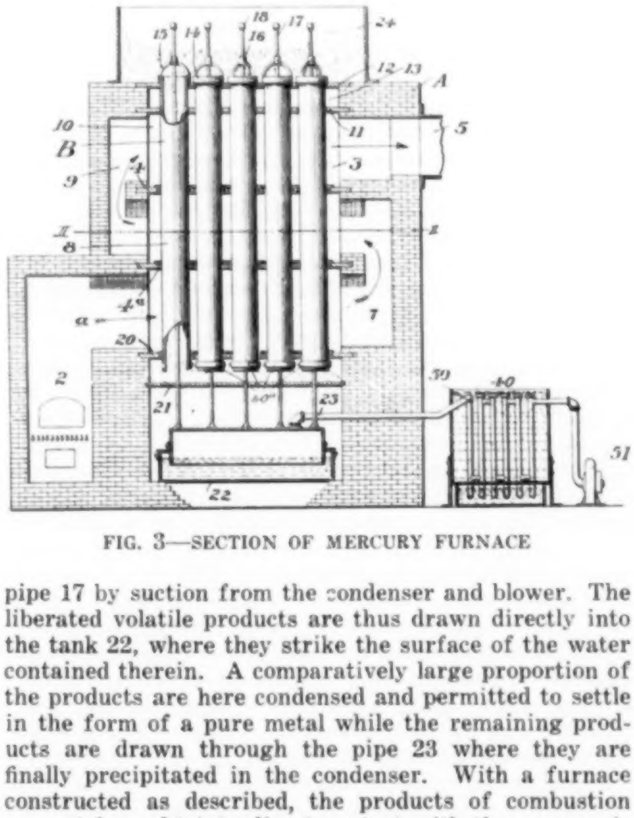


FIG. 3—SECTION OF MERCURY FURNACE

pipe 17 by suction from the condenser and blower. The liberated volatile products are thus drawn directly into the tank 22, where they strike the surface of the water contained therein. A comparatively large proportion of the products are here condensed and permitted to settle in the form of a pure metal while the remaining products are drawn through the pipe 23 where they are finally precipitated in the condenser. With a furnace constructed as described, the products of combustion are not brought into direct contact with the ore nor is the ore raised to a temperature which will liberate the injurious corrosive gases such as sulfurous or sulfuric acid. (1,222,251, April 10, 1917.)

Calcium Carbide

Calcium Carbide and By-product Recovery Furnace.—An electric furnace, adapted to produce calcium carbide and coal tar products is patented by J. H. REID of Newark, N. J., and assigned to the Patents Process Company, a Maine corporation. A cross-section of the furnace and condenser is shown in Fig. 4. The furnace proper is simple in construction. From the cover, extends the outlet 18 provided with the fluid seal 19 and the revolving damper 20. The upper section or cover 9 is also provided with a sealed feed inlet 21 the seal of which may be removed and replaced while supplying ingredients to the apparatus during the performance of the process and closed during the condensing operation. The outlet 18 with its fluid seal 19 communicates with a removable conduit 25 operating

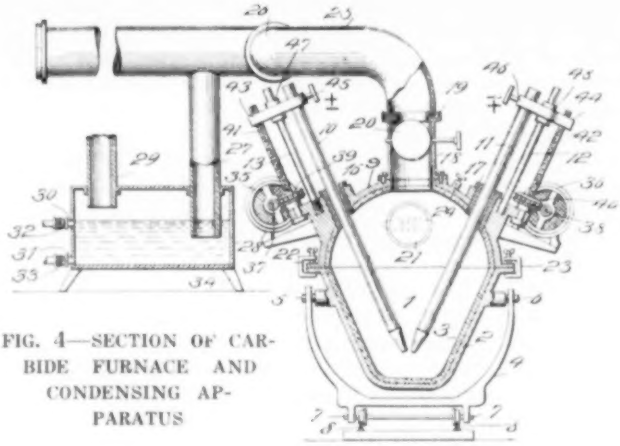


FIG. 4—SECTION OF CARBIDE FURNACE AND CONDENSING APPARATUS

through the swinging joint 26. This conduit communicates with an outlet 27 leading to the reservoir 28 and through which the condensed volatile products pass to the same, the reservoir 28 being provided with an outlet 29 for the permanent gases and whereby the said gases are conveyed to a reservoir (not shown). The apparatus is stated to be applicable to the production of calcium carbide from bituminous shale and lime, with the recovery of tar or volatile products such as benzol, toluol, etc., evolved during the action of the electricity on the charge. (1,224,788, May 1, 1917.)

Welding

Welding Compound for Nickel and Nickel Alloys.—A flux for use in the autogenous welding of nickel and nickel alloys is patented by RICHARD SAMESREUTHER, of Dusseldorf, Germany. The object of using the flux is to overcome the absorption of oxygen and other gases and embrittling of the welded piece on cooling. Porosity is also claimed to be overcome. The essence of the invention is that in order to effect a proper welding of nickel or nickel alloys, there must be present (in addition to metal of the same character as the one to be welded) three substances or ingredients, viz. first, alkali, second metal chloride, and third, chromium. The purpose of the alkali is, stated above, to form a fireproof film during welding. This film, however, would prevent the parts to be welded from fusing together, and to avoid this detrimental action, metal chlorid and chromium are used during the welding process. Waterglass may be used as the alkali and chlorides of magnesium or molybdenum as the metal chlorides. Chloride of calcium may also be added to dissolve any possible slags. (1,224,418, May 1, 1917.)

Light Alloys

Aluminium-Calcium Alloys.—Aluminium-calcium alloys and the process of manufacture are patented by HUGH S. COOPER, of Cleveland, Ohio, (assigned to the Cooper Company, of Cleveland, Ohio). An alloy of 8 to 10 per cent calcium and the balance aluminium which is the favored composition is much lighter than aluminium alone, is stated to be much harder, more resistant to corrosion and to machine easily. The calcium also acts as a deoxidizer. The process of manufacture is described in the specification as follows:

> In view of the fact that calcium burns, even when heated to a low temperature, the alloy cannot be made by simple fusion of the mixed metals. Consequently, the steps practised by me in making these alloys is to melt the aluminum first and heat to about 800 C. The melted product is then removed from the fire and calcium in the form of small pieces pushed under the surface of the melted aluminum and held there until melted. Upon the introduction of each piece of calcium a slight reaction takes place with a rise in temperature of the melt, and when the proper amount has been added the alloy is stirred rapidly and immediately poured into molds. Care must be taken that the calcium does not float on the surface of the aluminum, as in this case it would rapidly burn to the oxid without formation of alloys. After the melted aluminum has been removed from the fire, the introduction of each calcium piece produces a reaction which generates sufficient heat to keep the alloy in a melted condition until all the needed calcium has been added.

The alloys are especially useful for the manufacture of light castings for automobiles, aeroplanes, etc. (1,224,362, May 1, 1917.)

Iron and Steel

Ferro-alloys and High Speed Steel.—Two patents of ISADOR LADOFF, of Wilkinsburg, Pa., deal with the production of ferroalloys and high speed steel. The first (No. 1,221,873, April 10, 1917), describes a method of making ferroalloys by heating a mixture of the oxides of the metals in proportions calculated to insure the desired percentage of the metals in the alloy. Thus, for instance, uranium, chromium, vanadium, and iron oxide, may be used. To this mixture is added an auxiliary oxide such as arsenic, antimony, nickel, or cobalt. The charge is then heated below the melting points of the metals in the presence of a reducing agent until the desired alloy has been produced. The auxiliary oxide mentioned above is claimed to render the alloying metals more miscible and therefore more readily alloyable. The second patent (No. 1,221,874, April 10, 1917) describes the production of high speed steel by producing in one heat a preliminary quaternary alloy of ferro-metal with tungsten, chromium and vanadium in the proper proportions and then melting the alloy in a bath of ferro metal not comprised in the alloy. The tungsten-chromium and vanadium constitute not less than 50 per cent of the preliminary alloy, which is produced by reducing the oxides of the constituent metals at temperatures below their melting points.

Youngstown Chemists' Club.—The Youngstown Chemists' Club closed a very successful season with a dinner Wednesday evening, May 16, followed by an excellent program. Mr. F. E. Dodge, chief chemist of the Barrett Co. gave a most interesting impromptu talk on "The Benzol Situation," Prof. H. E. Whitfeld of the University of Western Australia and British Inspector of Materials at Pittsburgh, explained some of the British methods of testing the materials for shells and other munitions. Mr. W. C. Anderson, chief chemist of the American High Explosive Co. of New Castle, Pa., spoke on "The Chemistry of High Explosives and Permissibles," exhibiting some very interesting samples.

Illinois Mining Engineers' Meeting.—The Illinois Mining Institute and Chicago Section of the American Institute of Mining Engineers held a joint meeting and field trip May 17, 18 and 19, with headquarters at La Salle, Ill., at the Hotel Kaskaskia. A meeting was held on Thursday afternoon, May 17, and a reception Thursday evening. Meetings were also held on Friday morning and evening, and a joint dinner Friday evening. On Friday afternoon and all day Saturday inspection trips were made to various plants and points of interest. The excursions included the works of the Marquette, Lehigh and German-American cement companies, the mines of the Illinois Zinc Co. and the La Salle County Carbon Coal Co., and the zinc smelting works of the Matthiessen & Hegeler Zinc Co., the Illinois Zinc Co. and the Mineral Point Zinc Co. These works produce spelter, sheet zinc, sulphuric acid, zinc oxide and acid phosphate..

The Supply of Platinum

The known supply of metals of the platinum group in the world is possibly 5,000,000 ounces. Estimates based on the official figures of production from Russia since 1843, which are taken as 25 per cent too low, and on the assumption that Russia has supplied 95 per cent of the world's output, indicate that the total quantity of crude placer platinum produced in the world since 1843 has been less than 4,632,000 troy ounces, or about 159 short tons.

Crude platinum is not pure, as it contains, besides iron, small amounts of one or all of the metals iridium, palladium, osmium, rhodium, and ruthenium. It is difficult to estimate the quantity of platinum in the world, but it is perhaps within reason to say that the platinum in the world's stock of metals of the platinum group amounts to 4,000,000 ounces.

From the most reliable information in the hands of the United States Geological Survey, it is estimated that the total quantity of platinum in the United States is about 1,000,000 ounces, besides which there is over 400,000 ounces of other metals of the platinum group, principally palladium, iridium, and rhodium.

In 1916 the crude platinum mined in Colombia, estimated at 25,000 ounces, was refined in the United States, and reports received from domestic refiners show that 28,088 ounces of metals of the platinum group was recovered by them from all sources, foreign and domestic, of which 24,518 ounces was platinum.

ESTIMATED WORLD'S PRODUCTION OF CRUDE PLATINUM, 1909-1916, IN TROY OUNCES

Country	1909	1910	1911	1912
Borneo and Sumatra	500	200	.....	.....
Canada	30	30	30	30
Colombia	6,000	10,000	12,000	12,000
New South Wales and Tasmania	440	332	470	778
Russia	264,000	275,000	300,000	300,000
United States	672	390	628	721
	271,642	285,952	313,128	313,529

Country	1913	1914	1915	1916
Borneo and Sumatra	200	*.....	*.....	*.....
Canada	50	30	100	60
Colombia	15,000	17,500	18,000	25,000
New South Wales and Tasmania	1,500	1,248	303	222
Russia	250,000	241,200	124,000	63,900
United States	483	570	742	750
	267,233	260,548	143,145	89,932

*No basis for estimate.

It is known that the Colombian deposits will be more extensively developed during 1917 than ever before, and it is estimated that at least 30,000 ounces of crude platinum, containing 85 per cent metal, will be derived from that source. It is hoped that in 1917 deposits in the United States will yield more platinum than heretofore, that platinum derived from all sources other than foreign crude may exceed 7000 ounces, and that the production of crude platinum will be at least 10 per cent greater than in 1916.

The Russian situation is very difficult, but it is known that there are considerable stocks of crude platinum held in Russia which are available to the allied governments. It is believed that the production from Russia in 1917 will be considerably increased, perhaps equaling the 1915 output.

Apparently the normal requirements of platinum in the United States call for 165,000 ounces a year, part of which is supplied by refining scrap and sweeps from the various industries using platinum. It is estimated that the dental industry formerly used between 25 and 30 per cent of the supply, part of which cannot be considered as recoverable. However, dental manufacturers are now using a number of alloys in place of platinum. It is estimated that the jewelry industry uses between 40 and 50 per cent of the supply, practically all of which would be recoverable if necessity arose.

There is no available information concerning the quantity of platinum in chemical utensils in the many hundred laboratories throughout the United States, but it is probably not much over 10 or 15 per cent of the supply and is all recoverable.

In 1915 about 44,000 ounces, or 4 per cent of the apparent United States stock of platinum, was used in contact-process sulphuric acid works. The acid made in these plants is very strong, and its use at this time is limited practically to munition makers. The production of sulphuric acid of grades in use in ordinary chemical industry does not depend on catalytic platinum, as such acid is made in lead chambers. The output of contact-process plants has increased nearly 200 per cent since 1915, and it is understood that plants using this process are not yet operated to their full capacity. It therefore would not appear that there is any pressing need for a large supply of platinum by the sulphuric-acid industry.

The Government laboratories are apparently well supplied with platinum utensils, and are not in the market for platinum at present, except as investigations on a larger scale may require new equipment. The United States mints are known to refine platinum and doubtless have stocks sufficient to meet any immediate governmental requirements.

A census of stocks of unmanufactured platinum in the United States that can be considered as immediately available is now being taken by the United States Geological Survey. From the information already available it would appear that there are supplies of platinum sufficient to meet such extensions of contact-process plants as may be required immediately.

From the foregoing statements the available supply of platinum in the United States appears to be adequate to meet immediate needs, but it should be emphasized that new demands may arise at any time which the present stocks of platinum in this country could not meet.

The jewelry industry has voluntarily agreed to limit the use of platinum in jewelry during the war.

It may be advisable to state that industrial expansion in the future may make necessary the further curtailment of platinum in the manufacture of jewelry in order that an adequate supply of this metal, which is essential in many chemical industries, may be assured.

Metallurgical Fellowships.—Dean Milnor Roberts of the College of Mines, University of Washington, announces that twenty applications for the mining and metallurgical research fellowships offered by the U. S. Bureau of Mines in connection with the University College of Mines, have been received. Winners of the scholarships will receive $720, and will conduct extended research study along lines of mining and metallurgical work that will be of special importance to the Pacific Northwest and Alaska.

Wood Oils.—The Forest Products Laboratory, Madison, Wis., has recently conducted considerable experimental work on wood oils. In the refining of crude hardwood distillates, the tar is distilled with steam to recover the acetic acid and alcohol, and during the distillation some light-gravity, low-boiling oils are also distilled over. These are commonly called "wood oils." It has been known for some time that these oils possessed very valuable solvent properties, but the very disagreeable odor and the permanent yellow color were very disadvantageous. It has been found by the Forest Products Laboratory that, by hydrogenation, the color can be very much improved and the odor changed to a distinctly agreeable ketone odor, and that this can be done without any marked change in the other physical or chemical properties.

A New Dry Concentrator

A new type of dry concentrator known as the Elsol concentrator has been designed and placed on the market by Young & Tyler of Los Angeles, Cal. It is stated that successful results have been obtained on gold, silver, lead, zinc, copper and antimony ores with this machine. A diagram is given in Fig. 1.

Ore from the hopper *C* is fed onto a specially constructed metal surface *F*, over which is a cover with pipe *K* attached, connected to settling cone *B*.

The bottom side of all riffles are perforated with a nozzle-like perforation placed at such angle as to not only give the lifting effect on the material (thus allowing the values having the higher specific gravity to settle to the bottom), but also to aid in a more rapid advance of the material along the riffles.

The exhaust, which draws fine dust up through pipe *K*, is furnished by connecting the return air pipe *E* to the tank *B*. The fine dust is discharged at *H*.

The riffles of the concentrator are of an obtuse angled V-shape with one side—the front or bottom side—longer than the other, and when in its working position a cross-section presents an appearance similar to that of the lip of an ordinary gold pan when being used by an expert panner.

At the upper or feed end of the table these riffles are of comparatively large cross-section and gradually taper down to a small cross-section at the concentrate-discharge end *G*. The object of this is twofold: It gives a greater longitudinal angle to the upper riffles, besides reducing the capacity per unit length of riffle as the discharge end is approached.

The greater longitudinal angle has the effect of holding the values more securely once they have been caught, since the riffle cuts more sharply across the line of travel of the table movement. The reduction of cross-section has the positive effect of eliminating the gangue matter which may be riding near the top of the riffle.

The table movement is accomplished by a set of eccentrics which together with a relatively high rotation give the rapid progressive movement of the material.

The concentrator is built in capacities ranging from 1 to 12 tons per hour on coarse crushed quartz ores, and from 2 to 40 tons per hour on ordinary gold placer. The capacity depends largely on the quality of the ore and upon the percentages of values carried, the lower the percentage of values the higher the capacity.

It is claimed that the horsepower required varies from less than 1 on the small size to $2\frac{1}{2}$ to 3 on the larger sizes.

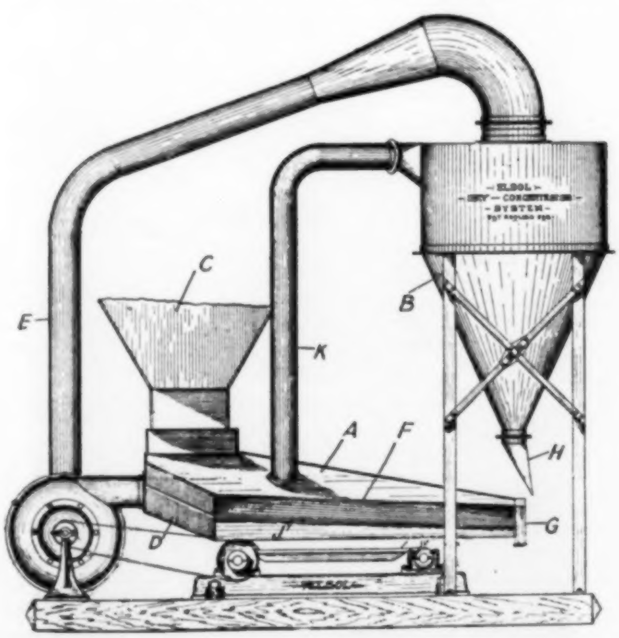


FIG. 1—DIAGRAM OF DRY CONCENTRATING SYSTEM

Oxy-Illuminating Gas Lead Burning Apparatus

Apparatus for lead-burning with oxygen and natural or artificial illuminating gas, known as "Astra" apparatus, has been developed by Ashton, Laird & Company of New York, and is being placed on the market through its agents, the Bradford-Ackermann Corporation, Forty-second Street Building, New York.

PORTABLE WELDING APPARATUS

Two standard models are made, a stationary and a portable type. The portable type is shown in Fig. 1. It includes a flexible metallic gas hose connected to the gas main and oxygen tank and to the regulator and torch, as shown. A working range of 18 ft. is provided by the hose, which can be increased by means of additional hose.

A specially designed pressure-reducing valve, with safety attachment, serves as the oxygen regulator. This is supplied with a gage to indicate the working pressure at the burning nozzle. A high-pressure gage, furnished separately, can be attached to determine the initial contents of the oxygen tank when received, or when it is nearly exhausted, or the quantity of gas used in each operation. The apparatus also includes an oxygen back-pressure release valve for the illuminating-gas line. This device, and the safety device on the oxygen regulator, operate automatically, and are provided with alarm whistles to attract attention.

The two-hose torch is provided with a valve, as shown, which can be used to shut off the oxygen supply between operations, leaving only the illuminating gas as a pilot light.

The apparatus is so assembled that its different component parts may be added to existing welding, or decarbonizing apparatus to provide lead burning facilities. Other Astra appliances may be added in order to include hard soldering, brazing, tempering, etc.

A New Hardness Tester

An instrument designed by Dr. Leonard Waldo for determining the hardness of metals under service conditions is shown in the illustration Fig. 1. The requirements of such an instrument are that it should be easily portable and that its indications should be uniform over indefinite periods of time, and subject to easy calibration.

The instrument consists of a plummet weighing 1/10 lb. and falling 1 ft. to the surface of the material whose hardness is to be measured. This plummet *P* shown in the illustration has a conical, replaceable, chill-tempered, 60 deg., steel point *G*. This plummet has tied to its upper extremity a very thin silk thread which bends over a funnel-shaped end piece *ABC*, into which, at *A* and *B*, slotted holes are cut with burnished edges such that the silk thread passes through them with practically no friction loss. The funnel *ABC* turns with a slight friction in the end of the jointed supporting brass tube *IC*. The silk thread is attached to a small burnished ring at its lower end, which ring in turn is caught in a little trigger at *H*, which can be released by the thumb screw *I* without jarring the instrument. The silk thread then passes from the release catch *K* through the hole *A*, through *B*, through an adjustable third hole at *E*, which is clamped in place by the thumb screw D so that the plummet point *G* is exactly over the aperture *O* in the base of the instrument.

The base of the instrument is supported on three points, two of which are controlled by leveling screws *J*. Small cross levels indicate the verticality of the supporting rod *IC*.

In use, the instrument is set on the surface of the material whose hardness is to be tested, so that the aperture in its base *O* is concentric with the exact spot to be tested. The plummet is then hung as shown, and lowered by holding the silk thread by its ring between the fingers so that the exact position of the clamp *DE* may be found for insuring the vertical fall of the plummet. This being determined, with the instrument leveled, the thread ring is placed in its releasing trigger *H*, and with the plummet in its position *FG*, the funnel support *AB* is gently turned until the distance from the conical point *G* to the surface of the material to be tested *O* is exactly 1 ft.

When the plummet is still the trigger is released by the thumbscrew *H*, and the plummet falls, making a uniform circular indentation in the material tested. The object in releasing the plummet from the bottom of the apparatus is to avoid disturbance in its upper support. A small portable microscope (Fig. 2) is then used. It is designed so that it has sufficient illumination and magnifying power to measure easily with an eyepiece micrometer the diameter of the impression made by the falling plummet point. A scale for measuring indentations is embodied in the microscope.

The apparatus is being placed on the market by the Palo Company, 90-94 Maiden Lane, New York City.

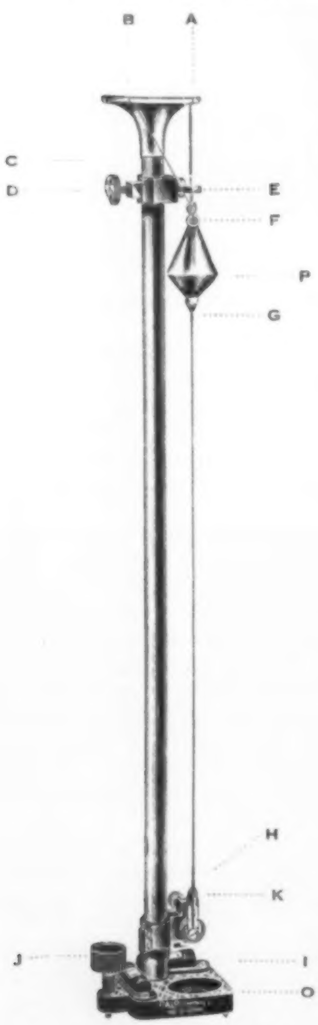


FIG. 1—WALDO HARDNESS TESTER

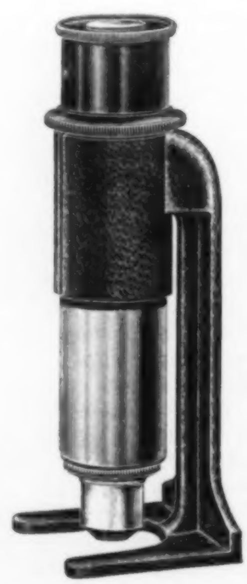


FIG. 2—SMALL PORTABLE MICROSCOPE

Cooling Condensing Water in a Dyestuff Plant

The desire for quick and rapid production of new dyestuffs and other chemical products in order to take advantage of the markets has made it necessary for a great many plants to adopt makeshifts for certain of their operations, which while giving the desired result would probably not be considered if the element of time did not enter so strongly into the work. The illustration, Fig. 1, shows a method adopted by one of the large vegetable dye concerns to cool the water used to condense vapors arising from the various processes. The method has been in successful operation since last October, cooling 200 gal. of water per minute from a boiling temperature to 70 to 90 deg. Fahr. The trough on the tank is 22 in. wide and its lip is 15 ft. from the reinforced concrete tank. The tank itself is about 20 ft. x 30 ft., and is 13 ft. deep.

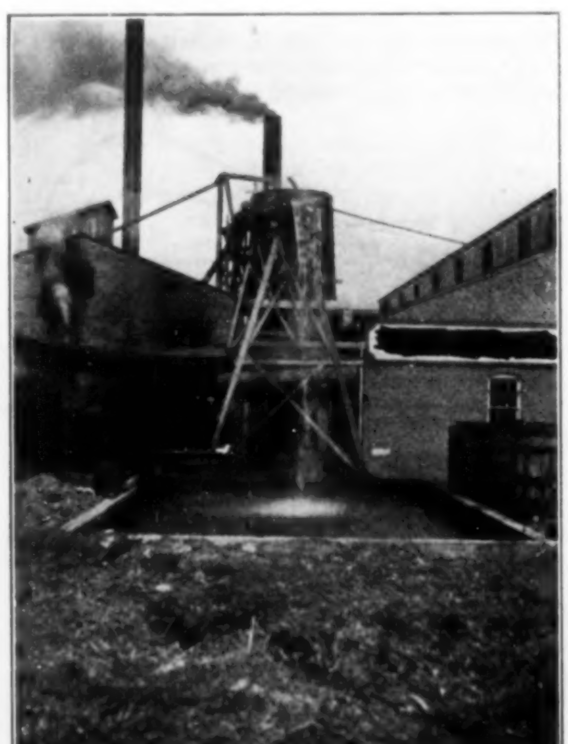


FIG. 1—HOT WATER TANK AND COOLING POND

Personal

Dr. **Marston T. Bogert** has been granted leave of absence from Columbia University and is devoting all his time to the work of the National Research Council, of which he is chairman of the Chemistry Committee. His headquarters are in the Munsey Building, Washington, D. C.

Dr. **Allerton S. Cushman,** president of the Institute of Industrial Research, Washington, D. C., has been commissioned a major in the Officers' Reserve Corps, and will do special research work under the ordnance section on the chemistry of high explosives.

Mr. **B. A. Foley** has terminated his connections as assistant manager with the Palo Company, and is now associated with the Lenz Apparatus Company, Inc., 9-11 East 16th Street, New York.

Mr. **H. A. Ford** has resigned his position as steam engineer with the Bethlehem Steel Co., South Bethlehem, Pa., to become assistant superintendent of the Union Carbide Co.'s plant at Sault St. Marie, Mich.

Mr. **J. H. Herron** has been elected president of the Cleveland Engineering Society. Messrs. **S. T. Wellman** and **Ambrose Swasey,** both past presidents, have been made honorary members of the society.

Mr. **Bernard MacDonald** has accepted an engagement which will occupy his time indefinitely as consulting engineer with headquarters at Antofagasta, Chile.

Mr. **Edwin S. Pettis** of the Oliver Continuous Filter Company, San Francisco, Cal., was recently in New York on business for his company. He reports great activity in the chemical field.

Mr. **E. Gybbon Spilsbury** sailed on June 5 for Central America and expects to be absent until the middle of July.

Mr. **V. C. Suckow,** chief inspecting engineer with Falkenburg & Laucks, Seattle, Wash., has received a captain's commission in the Engineers' Corps and has reported for duty at the Presidio at San Francisco.

Mr. **F. H. Tackaberry** has been appointed traveling representative of the American Steel Export Co. of New York. He has recently been associated with the Ordnance Engineering Corporation of New York and has occupied important executive positions in such organizations as the Industrial Underwriters, Inc., the Locke Steel Belt Co., etc.

Book Review

Standard Methods of Chemical Analysis. Edited by **Wilfred W. Scott.** Octavo (15 x 23 cm.), 864 pages, 145 illustrations. Price, $6.00 net. New York: D. Van Nostrand Company.

This dignified volume is intended for general reference for analytical chemists and advanced students. The editor is research chemist for the General Chemical Company, and has associated with himself seventeen competent specialists.

Part I takes up alphabetically the determination of the elements, all sections being written by Mr. Scott except "Cerium and Other Rare Earths," "Zirconium" and "Thorium," by R. Stuart Owens, "Chlorine" with the assistance of W. F. Doerflinger, "Copper" with the assistance of W. G. Derby of the Nichols Copper Company, "Gold" and "Silver" by W. G. Derby, "Nickel" by W. L. Savell, "Platinum and Allied Rare Metals" by R. E. Hickman of Bishop & Company, "Potassium and Sodium" by W. B. Hicks of the U. S. Geological Survey, "Tin" by H. A. Baker and B. S. Clark of the American Can Company, "Titanium" with the assistance of L. E. Barton of the Titanium Alloy Manufacturing Company, and "Zinc" by F. G. Breyer of the New Jersey Zinc Company.

Part II deals with special subjects, in which Mr. Scott himself writes on "Acids", D. K. French on "Water Analysis," A. H. Gill on "Fixed Oils, Fats and Waxes" and on "Gas Analysis," H. A. Gardner and J. A. Schaeffer on "Paints," R. K. Meade on "Cements," J. C. Olsen on "Alloys," F. E. Hale on "Coal" and W. G. Derby on "Assaying."

We find Part I more satisfactorily written than Part II. Under each element the treatment is broad and comprehensive, giving the general bases for determination of the element under varying conditions and in different combinations. The book would have been highly satisfactory if it had ended with Part I. The second part is sketchy and less satisfactory. Many special problems, such as the analysis of foods, asphalts, alloy steels, ferro-alloys, etc., which really require special treatment, are not touched, while those subjects which are treated are not always handled satisfactorily, e.g. alloys and assaying.

The book, as a whole, deserves a place in every chemical laboratory.

CURRENT MARKET REPORTS

The Iron and Steel Market

The lapse of a fortnight has furnished additional basis for the view expressed in last report that the steel market had gotten onto a new tack, with less disposition on the part of buyers to contract for late deliveries and less tendency for prices to advance.

The steel market, however, has always displayed an ability to cover up its tracks at a juncture like this, and the present is no exception. There develops, let us say, an indisposition on the part of buyers to contract for deliveries as far ahead as formerly, whereupon the sellers accept the situation and make not the slightest effort to encourage buyers by making price concessions, as they know perfectly well that such action would have the opposite effect. Meanwhile the demand for early deliveries continues on the part of those not fully covered, and as the early deliveries usually command premiums, the average price at which business is done tends to advance at a time when buyers are really displaying less confidence in the future. This is approximately the situation to-day. Some steel products are bringing higher prices than recently, for early deliveries, while ordinary forward buying is light.

The Steel Corporation's unfilled tonnage statement indicates that the volume of obligations on books is equal, in tonnage, to its production for nine months. The larger independents are in somewhat the same position. Some departments are sold much farther ahead, some not as far ahead. Obviously the buyer is taking a long chance in placing a contract for delivery after the present business is filled. The country may then be at peace or it may be facing the prospect of one or two years more of war. A period of market quietness is to be expected, even though consumption may be likely to continue at its present rate. Of this, however, there certainly must be considerable doubt.

The condition as to steel market prospects beyond the next few months is certainly a complicated and confusing one, and not the less so by the ready adoption in some quarters of various fallacies. On the one hand the urgent need for ships is taken as indicating heavy demand for steel for shipbuilding, while the corollary, that if ships are very scarce it will be difficult to export steel, is not considered. Again, the demand for steel for government account, building ships, making tent stoves, camp ranges, helmets, a thousand and one things,

is taken as adding so much to the total demand for steel, without allowance being made for the fact that all the steel must be fabricated or worked up in one way or another, largely with existing facilities, which to that extent can no longer be employed in fabricating the steel they have lately been taking. A factory working up steel may have its tonnage consumption reduced by its being turned onto Government work. The business is not necessarily so much addition. Another fallacy is that each ton the Government takes will correspondingly decrease the total supply of steel. As the industry is highly specialized, only so much steel can be put into sheets, so much into plates, into wire, and so on. Assume a manufacturer who makes a ware from sheets and bars in equal tonnages. Let the Government take sheets and not bars. For every ton of steel, in the sheet form, the Government takes, the factory consumes two tons less steel, because it cannot get the ton of sheets and therefore does not want the ton of bars either.

STEEL FOR GOVERNMENT

The Government requirements in steel are not being formulated rapidly. Some opinions must be altered. It has been found undesirable for the Government to buy steel and farm it out to factories and shops for conversion into the useful product. The purchases are to be made of the finished products, and it takes time to make them, so that the steel orders are percolating through to the steel mills rather slowly, in point of tonnage. When it is considered, however, that with a long war the business represents in each case not so much a specific tonnage as a rate per month, to be continued indefinitely, the proportion of the country's steel output that eventually will be passing to Government account seems likely to be larger than was at first estimated. Two months ago an altogether outside estimate was 20 per cent of the total output. If export shipments can be made freely to our Allies and things work well in the matter of finding fabricating capacity to turn rolled steel into useful forms the proportion may in time exceed 20 per cent and may conceivably reach 30 or 40 per cent.

STEEL PRICES

There is no longer any well-defined steel market. Formerly there were well-recognized prices for finished steel products for forward delivery, this developing practically into "delivery at mill convenience," but these prices first became nominal and then disappeared altogether. It is a question of tonnage, delivery and specification, every order with a price of its own. Roughly speaking, for delivery from three to six months hence tank plate is 7c. to 8c., with ship plates, Lloyd's specifications, in the neighborhood of 10c.; bars, 4c. to 4.25c.; structural shapes, 4c. to 4.50c.; blue annealed and black sheets, 7c. to 8c., galvanized sheets about 10c.; wire nails, \$3.50 to \$3.75. There is no tin plate market. The respectable mills, practically all, are devoting their output to taking care of the perishable food crops and have nothing to offer.

PIG IRON'S INNING

What was suggested a fortnight ago as possible, seems to be coming rapidly to pass. It is pig iron's inning. Throughout this movement, until very lately, the thin neck of the bottle was the steel making capacity. There was plenty of pig iron for the steel-making departments and plenty of rolling capacity—except in plates—for the ingots. Lately, conditions have been changing. Steel-making capacity has increased much more than blast-furnace capacity, and it is impossible for all the furnaces in blast to maintain full output continuously on account of shortage of coke, through car shortage in the Connellsville region and at coal mines supplying by-product ovens. This is the trade's interpretation of the sharp advances in pig iron. In the past fortnight the following advances have occurred: At valley furnaces, Bessemer, \$5; basic, \$3; foundry, \$2; foundry at Birmingham, \$2; at Philadelphia, \$1; at Chicago, \$3. Last sales of Bessemer were at \$50, valley, 35,000 tons altogether, while last sales of basic were at \$45, but at this writing there does not appear to be any more available and by June 15th the market may be established by sales at more than \$50 for each grade. It may be remarked that while higher than present prices for pig iron ruled late in the Civil War and for two or three years thereafter, \$50 Bessemer iron is the highest in recorded history, as there was no Bessemer iron at that time, as the market commodity, the first reported production of Bessemer steel having been in 1867, a couple thousand tons.

Non-Ferrous Metal Market

Friday, June 8.—Copper remains virtually unchanged. Tin has declined following a decline in London. Lead has been advanced \$10 per ton by the Trust. Spelter is unchanged. Antimony has declined further on freer offerings. Silver has advanced slightly.

Copper.—Prices for prompt and June copper remain practically unchanged with Electrolytic averaging 31.50 cents and Lake 32.50 cents. The strike at Jerome, Arizona was settled June 4, and 1500 men returned to work. At the time of writing no announcement has come of the prices to be paid for copper purchased by the Government. A census is undoubtedly being taken of the possible production during the year and of consumers' requirements. July electrolytic is offered at 31.50 to 32.00 cents, third quarter at 30.00 cents and fourth quarter at 29.00 cents.

Tin.—The market in London declined considerably the first week in June, but on June 7 began to recover. Our prices followed those abroad and spot Straits dropped from 65.00 cents on May 28 to 60.50 cents on June 6, but recovered to 61.00 cents on June 7. The market has been quiet and futures have been very dull. The uncertainty as to the tax and the British regulations have had a dampening effect, but it is hoped that the Tin Committee, appointed as a sub-committee of the Council of National Defense will straighten out the tin situation. At present the committee is obtaining data on stocks and requirements of consumers. Arrivals for May were good, totalling 5895 tons. Deliveries at Atlantic and Pacific ports were 4200 tons.

Lead.—The trust price of lead was advanced to 10.50 cents New York on June 7. The advance was expected and follows a long period of scarcity of supplies. It is reported that increased production in this country and in Mexico should have its effect before long in the lead market, although there are no signs yet of any let up in demand.

Spelter.—Buying continues very dull with spot spelter unchanged at 9½ cents New York basis. It is understood that production is on a smaller scale. Futures up to fourth quarter are quoted at the same figure as prompt shipment.

Other Metals.—Antimony has declined from 23.25 on May 28 to 20.75 on June 7. There has not been much demand for prompt, but futures are in good demand. For July shipment 19.00 cents is asked and 18.00 cents for August. Aluminium is unchanged at 60.00 cents for No. 1 Virgin. Magnesium can be had at \$2.25 to \$2.50 for prompt shipment, and for less on contract. Quicksilver is \$90.00 per flask. Pure platinum is \$105 per ounce. Silver is 75⅜ cents per ounce. Tungsten concentrates are \$17 00 per unit for wolframite and \$17.50 for scheelite.

Chemical Market

Coal-Tar Products.—Business in practically all items under this classification has been much restricted during the past two weeks, due to the general unsettled conditions prevailing. The possibility of a 10 per cent duty on free and dutiable goods tends to hold up transactions on English products, and the uncertainties governing war purchases on the other hand tend to restrict offers of domestic materials entering into the manufacture of munitions.

Benzol.—In contrast to the situation that prevailed only a short time ago, supplies of benzol have been quite abundant during the interval, and even the large producers have found difficulty in disposing of their holdings. Consequently, there has been but little activity noted, and the market has exhibited a rather weak tone, with some tendency to firmness at the moment of writing.

Aniline Oil.—The situation has been rather peculiar. After a period of extreme firmness for more than a month the demand experienced a lull, and a holder of one car possessed the product for more than a week without selling it. As soon as this material was cleared from the market, however, a feeling of firmness ruled, and the market advanced somewhat. Generally speaking, the outlook for aniline oil is bright, and there is a probability that higher prices are to prevail. Some producers who dropped out when low prices ruled have come back, and are now offering in a moderate way.

Monochlorbenzol.—There has been nothing of special note to report regarding this product. Supplies have increased and offerings have in some instances been made on a much lower level than any heretofore prevailing. Production now is quite important, and will probably increase.

Toluol.—In contrast to benzol, the toluol market is quite stiff, and prices have ruled on a higher level. In anticipation of important government business, holders are not inclined to dispose of their holdings, and have, turned down big business. Prices have been stiff.

Toluidines.—There has been no important change to record with important sales noted of *para*, with *ortho* somewhat restricted in demand. Mixed *toluidine* has practically disappeared from the market, although some inquiry is still noted.

Phenol.—The production continues to increase and in excess of the demand. Middle Western producers have been offering at prices somewhat below those prevailing in the East, and producers generally do not appear to be very well pleased with the situation, which has shown practically no important movement for months past.

Dinitrophenol.—Offerings of this product have been restricted. Values have remained moderately firm, but nothing of special importance has transpired.

Naphthalene.—English flakes are still offered at low prices in bond, but do not appear to attract much consuming inquiry. Prime domestic flakes are rather firm, but are not changed materially since our last report.

Paradichlorbenzol.—To use a pun, this product is a drug on the market. As a by-product, supplies are accumulating rapidly, and some holders have expressed a willingness to dispose of holdings at any reasonable price a buyer will set.

Paranitrophenol.—The manufacture of this product appears to be confined to one source, and there is good demand reported at favorable prices. *Ortho*, on the other hand, drags, and sales are difficult.

Heavy Chemicals.—Business has been small and unimportant during the intervals, with prices generally higher, but in some instances notably lower.

Bleaching Powder.—An extremely weak condition prevails, due it is stated to an important production by consumers from their own cells. There has been little export business, and the paper mills have been reselling contracts.

Caustic Soda.—In contrast, the market for caustic rules high, but the speculative interest is still pronounced, and it is predicted that when this element is eliminated a break will occur.

Soda Ash.—The market has not been particularly strong. A fair demand has prevailed, but prices remain about stationary. Some inquiry for 1918 has prevailed. Dense ash is in urgent demand, and high.

Formaldehyde.—The market has probably reached its highest point. It continues strong, however, but there seems to be little likelihood of any consumer paying more than present record prices.

Zinc Oxide.—A sharp advance has occurred, and supplies continue very scarce, with many important inquiries still unfilled.

Cyanides.—With the exception of potassium, all grades have ruled weaker in face of important Japanese competition.

Copper Sulphate.—While business has not reached important proportions, prices rule steady, and producers are quite firm in their views.

Barium Compounds.—There has been a rather brisk inquiry for these products, particularly the carbonate.

Carbonate of Potash.—Short interests find difficulty in covering. Their supplies are very light and prices high.

Acetate of Soda.—The demand has improved materially, and more money has been secured.

Phosphate of Soda.—Offerings have not been as free as heretofore and the commercial variety shows an advance in price.

Acids.—All grades of *acetic* are higher, with supplies scarce. There has been more activity noted in *muriatic*, and prices are higher in some directions. *Nitric* has been higher, due to the increased cost of raw materials rather than to any increased activity. *Sulphuric*, both pyrites and brimstone, has been firm and fairly active. *Oleum*, however, is somewhat off, owing to an increased output.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET JUNE 7, 1917

Acetic anhydride	lb.	1.70	—	1.80
Acetone, drums	lb.	.27	—	.27½
Acid, acetic, 28 per cent	lb.	.05	—	.05½
Acetic, 56 per cent	lb.	.09½	—	.10
Acetic, glacial, 99½ per cent, carboys	lb.	.31	—	.32
Boric, crystals	lb.	.11	—	.11½
Citric, crystals	lb.	.73½	—	.75
Hydrochloric, commercial, 18 deg	lb.	.01⅜	—	.01½
Hydrochloric, 20 deg	lb.	.01½	—	.01¾
Hydrochloric, C. P., conc., 22 deg	lb.	.01⅝	—	.01¾
Hydrofluoric, 30 per cent, in barrels	lb.	.04¾	—	.05
Lactic, 44 per cent	lb.	.11	—	.12
Lactic, 22 per cent	lb.	.04½	—	.05
Nitric, 36 deg	lb.	.06½	—	.07
Nitric, 42 deg	lb.	.07½	—	.08
Oxalic, crystals	lb.	.46	—	.47
Phosphoric, 85 per cent	lb.	.33	—	.37
Picric	lb.	.70	—	.75
Pyrogallic, resublimed	lb.	3.50	—	4.00
Sulphuric, 60 deg.	ton	20.00	—	22.00
Sulphuric, 66 deg	ton	30.00	—	35.00
Sulphuric, oleum (Fuming), tank cars	ton	35.00	—	40.00
Tannic, U. S. P., bulk	lb.	.45	—	.50
Tartaric, crystals	lb.	.79	—	.82
Alcohol, grain, 188 proof	gal.	3.06	—	3.08
Alcohol, wood, 95 per cent	gal.	1.00	—	1.02
Alcohol, denatured, 180 proof	gal.	.72	—	.73
Alum, ammonia lump	lb.	.04	—	.04½
Alum, chrome ammonium	lb.	.18	—	.19
Alum, chrome potassium	lb.	.30	—	.32
Alum, chrome sodium	lb.	.12	—	.12½
Alum, potash lump	lb.	.06½	—	.07
Aluminium sulphate, technical	lb.	.02	—	.02½
Aluminium sulphate, iron free	lb.	.03	—	.03¼
Ammonia aqua, 26 deg. carboys	lb.	.06½	—	.07
Ammonium carbonate	lb.	.13	—	.14
Ammonium nitrate	lb.	.16	—	.17
Ammonium, sulphate domestic	lb.	5.80	—	5.90
Amyl acetate	gal.	4.00	—	4.25
Arsenic, white	lb.	.18	—	.19
Arsenic, red	lb.	.30	—	.60
Barium chloride	ton	80.00	—	90.00
Barium sulphate (Blanc Fixe, powder)	lb.	.04	—	.04½
Barium nitrate	lb.	.11	—	.11½
Barium peroxide, 80 per cent	lb.	.27	—	.27½

Bleaching powder, 35 per cent chlorine	lb.	.02	—	.02½
Borax, crystals, sacks	lb.	.08	—	.08½
Brimstone, crude	ton	45.00	—	....
Bromine, technical	lb.	.80	—	.90
Calcium, acetate, crude	lb.	.03	—	.03½
Calcium, carbide	ton	80.00	—	90.00
Calcium chloride, 70-75 per cent, fused, lump	ton	26.00	—	28.00
Calcium peroxide	lb.	1.80	—	1.90
Calcium phosphate	lb.	.30	—	.31
Calcium sulphate	lb.	.01	—	.02
Carbon bisulphide	lb.	.04¼	—	.04½
Carbon tetrachloride, drums	lb.	.15½	—	.16
Caustic potash, 88-92 per cent	lb.	.85	—	.86
Caustic soda, 76 per cent	100 lb.	6.40	—	6.45
Chlorine, liquid	lb.	.15	—	.18
Cobalt oxide	lb.	1.55	—	1.60
Copperas	100 lb.	1.05	—	1.10
Copper carbonate	lb.	.33	—	.35
Copper cyanide	lb.	.72	—	.74
Copper sulphate, 99 per cent, large crystals	lb.	.09½	—	.10
Cream of tartar, crystals	lb.	.48	—	.49
Epsom salt, bags	100 lb.	4.25	—	4.50
Formaldehyde, 40 per cent	lb.	.17	—	.18
Glauber's salt	100 lb.	.65	—	.70
Glycerine, bulk, C. P	lb.	.61	—	.62
Iodine, resublimed	lb.	3.50	—	.....
Iron oxide	lb.	.02	—	.08
Lead, acetate, white crystals	lb.	.16	—	.17
Lead arsenate	lb.	.12¾	—	.13½
Lead nitrate	lb.	.17	—	.18
Litharge, American	lb.	.08	—	.19
Lithium carbonate	lb.	1.02	—	1.05
Manganese dioxide, U. S. P	lb.	.55	—	.60
Magnesium carbonate, tech	lb.	.13	—	.14
Nickel salt, single	lb.	.14	—	.14½
Nickel salt, double	lb.	.11	—	.12
Phosphorus, red	lb.	1.12	—	1.15
Phosphorus, yellow	lb.	1.25	—	1.30
Potassium bichromate	lb.	.35	—	.36
Potassium bromide granular	lb.	1.00	—	1.05
Potassium carbonate calcined, 80-85 per cent	lb.	.60	—	.70
Potassium chlorate, crystals	lb.	.56	—	.57
Potassium cyanide, 98-99 per cent	lb.	2.15	—	2.20
Potassium iodide	lb.	2.90	—	2.92
Potassium muriate 80-85 p. c. basis of 80 p. c	ton	375.00	—	400.00
Potassium nitrate	lb.	.30	—	.34
Potassium permanganate	lb.	4.00	—	4.10
Potassium prussiate, red	lb.	2.60	—	2.70
Potassium prussiate, yellow	lb.	.96	—	1.05
Potassium sulphate, 90-95 p. c. basis 90 p. c.	ton	350.00	—	375.00
Rochelle salts	lb.	.37½	—	.38½
Sal ammoniac, gray gran	lb.	.11	—	.12
Sal ammoniac, white gran	lb.	.17	—	.18
Sal soda	100 lb.	1.10	—	1.20
Salt cake	100 lb.	.90	—	1.00
Silver cyanide	oz.	.70	—	.....
Silver nitrate	oz.	.46⅛	—	.....
Soda ash, 58 per cent, light, flat	100 lb.	2.80	—	3.00
Soda ash, 58 per cent, dense, flat	100 lb.	3.90	—	4.00
Sodium acetate	lb.	.09	—	.10
Sodium benzoate	lb.	5.00	—	5.50
Sodium bicarbonate, domestic	100 lb.	2.10	—	2.20
Sodium bicarbonate, English	lb.	.....	—	.....
Sodium bichromate	lb.	.15	—	.15½
Sodium bisulphite, powd	lb.	.03½	—	.04
Sodium chlorate	lb.	.24½	—	.25
Sodium cyanide	lb.	.70	—	.75
Sodium fluoride, commercial	lb.	.13	—	.14
Sodium hyposulphite	lb.	.01¾	—	.02
Sodium nitrate, refined	lb.	.05½	—	.05¾
Sodium nitrite	lb.	.39	—	.43
Sodium peroxide	lb.	.90	—	.95
Sodium phosphate (tri.)	lb.	.04½	—	.04¾
Sodium prussiate, yellow	lb.	.30	—	.31
Sodium silicate, liquid—40 deg. Baumé	100 lb.	1.50	—	1.60
Sodium sulphide, 30 per cent crystals	100 lb.	1.55	—	1.70
Sodium sulphide, 60 per cent, fused	100 lb.	2.60	—	3.00
Sodium sulphite	lb.	.03¼	—	.03½
Strontium nitrate	lb.	.28	—	.30
Sulphur chloride, drums	lb.	.06	—	.06½
Sulphur dioxide, liquid, in cylinders	lb.	.12	—	.14
Sulphur, flowers, sublimed	100 lb.	3.20	—	3.30
Sulphur, roll	100 lb.	2.55	—	2.60
Sulphur, crude	ton	45.00	—	46.00
Tin bichloride, 50 deg	lb.	.19¾	—	.20
Tin oxide	lb.	.66	—	.70
Tungstic acid, basis 100 per cent	lb.	1.40	—	1.50
Zinc carbonate	lb.	.25	—	.27
Zinc chloride	lb.	.10¼	—	.11
Zinc cyanide	lb.	.50	—	.....
Zinc dust, 350 mesh	lb.	.18	—	.20
Zinc oxide, American process XX	lb.	.17	—	.20
Zinc sulphate	lb.	.06	—	.05½

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.55	—	.60
Benzol, 90 per cent	gal.	.57	—	.59
Toluol, pure, water white	gal.	1.90	—	2.00
Xylol, pure, water white	gal.	.50	—	.55
Solvent naphtha, water white	gal.	.17	—	.20
Solvent naphtha, crude, heavy	gal.	.13	—	.16
Creosote oil, 25 per cent	gal.	.31	—	.33
Dip oil, 20 per cent	gal.	.29	—	.30
Pitch, various grades	ton	8.00	—	20.00
Carbolic acid, crude, 95-97 per cent	lb.	1.05	—	1.10
Carbolic acid, crude, 50 per cent	lb.	.55	—	.60
Carbolic acid, crude, 25 per cent	lb.	.30	—	.32
Cresol, U. S. P	lb.	.25	—	.....

Intermediates, Etc.

Alpha naphthylamine	lb.	.90	—	1.05
Aniline oil	lb.	.29	—	.31
Aniline salts	lb.	.34	—	.35
Anthracene, 80 per cent	lb.	.10	—	.....
Benzaldehyde	lb.	4.50	—	5.00
Benzidine, base	lb.	1.85	—	2.00
Benzidine, sulphate	lb.	1.65	—	1.70
Benzoic acid	lb.	5.50	—	7.00
Benzyl chloride	lb.	2.00	—	2.10
Beta naphthol benzoate	lb.	14.00	—	16.00
Beta naphthol, sublimed	lb.	.70	—	.75
Beta naphthylamine com	lb.	2.50	—	.....
Dichlor benzol	lb.	.22	—	.23
Dinitrochlorbenzol	lb.	.46	—	.48
Dimethylaniline	lb.	.55	—	.60
Diphenylamine	lb.	.95	—	1.00
H-acid	lb.	3.25	—	3.50
Metaphenylenediamine	lb.	1.60	—	1.65
Monochlorbenzol	lb.	.28	—	.32
Naphthalene, flake	lb.	.09½	—	.10
Naphthionic acid, crude	lb.	1.50	—	1.75
Nitro naphthaline	lb.	.45	—	.50
Nitro toluol	lb.	.55	—	.60
Ortho-amidophenol	lb.	....	—	.....
Ortho-toluidine	lb.	1.00	—	1.15
Para-amidophenol, base	lb.	5.00	—	6.00
Paranitraniline	lb.	1.15	—	1.20
Paraphenylenediamine	lb.	3.50	—	3.75
Para toluidine	lb.	1.90	—	2.00
Phenol, U. S. P	lb.	.40	—	.42
Resorcin, technical	lb.	8.50	—	9.00
Resorcin, pure	lb.	16.00	—	17.00
Salicylic acid	lb.	1.15	—	1.20
Salol	lb.	1.70	—	1.75
Sulphanilic acid	lb.	.31	—	.33
Tolidin	lb.	3.00	—	.....
Toluidine-mixture	lb.	.80	—	.85

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	3.10	—	....
Corning, Ohio	bbl.	2.40	—	....
Somerset, Ky	bbl.	2.20	—	....
Wooster, Ohio	bbl.	2.18	—	....
Indiana	bbl.	1.78	—	....
Illinois	bbl.	1.92	—	....
Oklahoma and Kansas	bbl.	1.70	—	....
Caddo, La., light	bbl.	1.90	—	....
Corsicana, Tex., light	bbl.	1.70	—	....
California	bbl.	.78	—	.87
Gulf Coast	bbl.	1.00	—	....

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.13½	—	.14
Cylinder, light	gal.	.21	—	.26
Cylinder, dark	gal.	.18	—	.19
Paraffine, high viscosity	gal.	.29½	—	.30
Paraffine, .903 sp. gr	gal.	.21½	—	.22
Paraffine, .865 sp. gr	gal.	.18½	—	.19

Flotation Oils

(Prices at New York)

Pine oil, steam distilled, sp. gr. 0.925-0.940	gal.	.52	—	....
Pine oil, destructively distilled, sp. gr. 0.920-0.940	gal.	.48	—	....
Pine-tar oil, sp. gr. 1.025-1.035	gal.	.25½	—	....
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	.35	—	....
Pine oil, light, sp. gr. 0.950, tank cars, f.o.b. works	gal.	.37	—	....
Pine oil, heavy, sp. gr. 1.025, tank cars, f.o.b. works	gal.	.26	—	....
Pine tar, thin, sp. gr. 1.060-1.080	gal.	.22	—	....
Turpentine, crude, sp. gr. 0.980-1.000	gal.	.40	—	....
Hardwood oil, f.o.b. Michigan, sp. gr. 0.960-0.990	gal.	.19	—	....
Hardwood oil, f.o.b. Michigan, sp. gr. 1.06-1.08	gal.	.19	—	....

Vegetable and Other Oils

China wood oil	lb.	.16	—	.16½
Cottonseed oil, crude	gal.	1.11	—	....
Linseed oil, raw, cars	gal.	1.20	—	....
Peanut oil, crude	gal.	1.15	—	....
Rosin oil, first run	gal.	.38	—	....
Rosin oil, fourth run	gal.	.67	—	....
Soya bean oil, Manchuria	lb.	.14½	—	....
Turpentine, spirits	gal.	.49	—	....

Miscellaneous Materials

Barytes, floated, white, foreign	ton	38.00	—	40.00
Barytes, floated, white, domestic	ton	28.00	—	32.00
Beeswax, white, pure	lb.	.55	—	.60
Carnauba wax, flor	lb.	.51	—	....
Casein	lb.	.19	—	.28
Chalk, light, precipitated, English	lb.	.03	—	.06
Feldspar	ton	8.00	—	12.00
Fuller's earth, powdered	100 lb.	1.00	—	1.50
Ozokerite, crude, brown	lb.	.60	—	.70
Ozokerite, American	lb.	.35	—	....
Red lead, dry, carloads	lb.	.12	—	....
Rosin, 280 lb	bbl.	6.40	—	....
Soapstone	ton	10.00	—	12.50
Talc, American, white	ton	10.00	—	13.00
White lead, dry	lb.	.10½	—	....

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	Nominal		
Chrome cement, Grecian	net ton	60.00	—	....
Clay brick 1st quality fireclay	per 1000	45.00	—	....
Clay brick, second quality	per 1000	30.00	—	....
Magnesite, raw	ton	30.00	—	35.00
Magnesite, calcined	ton	40.00	—	55.00
Magnesite, Grecian, dead burned	net ton	90.00	—	....
Magnesia brick, Grecian, 9x4½x2½	net ton	140.00	—	....
Silica brick	per 1000	45.00	—	....

Ferroalloys

Ferrochromium	lb.	Nominal		
Ferromanganese, domestic, delivered	ton	425.00	—	450.00
Ferromanganese, English	ton	200.00	—	....
Ferromolybdenum, per lb. of Mo	lb.	4.25	—	....
Ferrosilicon, 50 per cent, carloads, del., Pittsburgh	ton	240.00	—	250.00
Ferrosilicon, 50 per cent, contract	ton	100.00	—	....
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh	lb.	2.00	—	....
Ferrovanadium, f.o.b. works	lb.	3.25	—	3.50

INDUSTRIAL

Financial, Construction and Manufacturers' News

Financial

New Companies

Argus Mining Company, Sandpoint, Idaho, has been incorporated with capital of $800,000, and L. E. Myers, G. B. Hoyt, W. D. Boyce, incorporators, to buy, sell and lease mines and mining property, coal and timber lands, operate sawmills, power plants and smelters.

Azadon Corporation has been incorporated with a capital of $140,000 to acquire and market petroleum. The incorporators are F. D. Buck, M. L. Horty, K. E. Longfield, Wilmington, Del.

Bassick Company, Bridgeport, Conn., has been incorporated with a capital of $6,000,000 to manufacture iron and steel, copper, wood and other material.

The Bellwood Foundry & Machine Company, Bellwood, Pa., has been incorporated with a capital of $20,000. Geo. C. Bland of Tipton, incorporator.

B. Brown & Bro., Inc., New York City, has been incorporated with a capital of $100,000 to deal in and manufacture oils, chemicals and colors. The incorporators are J. C. Brown, D. R. Bernstein, I. Skutch, 998 Sterling Place, Brooklyn.

California Burdett Oxygen Company has been incorporated with a capital of $500,000 to manufacture oxygen, hydrogen and other gases. The incorporators are H. E. Latter, H. M. Robinson, C. M. Egner, Elkton, Md.

Central Glass Company, Delaware, has been incorporated with a capital of $1,000,000 to manufacture glass of all kinds. The incorporators are H. E. Latter, C. H. Rimlinger, C. M. Egner, local Wilmington incorporators.

Chemical Securities Company has been incorporated in Delaware with $7,500,000 capital. Will conduct an investment business.

Commercial Iron & Steel Corporation, Delaware, has been incorporated with 1000 shares of no par value. J. R. Munoz, representative, 115 Broadway, New York.

The Corrugated Fibre Mills, Inc., Brooklyn, N. Y., has filed articles of incorporation with capital of $100,000 to manufacture paper corrugated and fiber board. J. B. Golan, L. Levine and J. C. Cassett, 27 Pine Street, New York, are the incorporators.

The DeWano Chemical Company, Newark, N. J., has filed articles of incorporation with capital of $25,000 to manufacture chemicals. The incorporators are Nathaniel A. Clinger, William G. Amdur and William H. Reardon.

J. E. Dockendorff & Co., Inc., New York, has been incorporated with a capital of $500,000 to manufacture iron, steel, copper and wood articles. The incorporators are J. E. Dockendorff, R. A. Young, J. R. Clark, Jr., 120 Broadway.

The Dodge-Weldon Iron Company, 15 Exchange Place, Jersey City, N. J., has filed articles of incorporation with capital of $540,000, to operate mining properties. The incorporators are: Andrew L. Meyer, 322 West 145th Street, New York, and Harry Osborne, 1297 Putnam Avenue, Brooklyn; Joseph F. Simpson, 440 Riverside Drive, New York.

Elliott-Blair Steel Company, Pittsburgh, Pa., has been incorporated with a capital of $500 000 to deal in steel. The incorporators are George D. Blair, N. W. Elliott, Thomas C. Elliott, New Castle.

Fine Colors Company, Van Houton Street, Paterson, has been incorporated with a capital of $30,000 to manufacture lake and pigment colors.

Fish Products Company, Inc., New York, has been incorporated with a capital of $200,000 to manufacture oils and fertilizing materials. The incorporators are E. Seligman, W. G. Weichmann, A. Jaretzki, Jr.

Gasoline Oil Refining Company, New York, has been incorporated with a capital of $2,500,000 to drill and bore for oil and natural gas. The incorporators are F. D. Buck, M. L. Horty, K. E. Longfield, of Wilmington, Del.

Gibson Consolidated Copper Company, New York, has been incorporated with a capital of $1,000,000. The incorporators are Allen E. Moore, George F. Jebbett, F. H. Buethorn, of New York.

The International Marine Welding Company, Dover, Del., has been incorporated with capital of $200,000 by New Jersey interests to operate a welding plant to specialize in marine work. The incorporators are Charles R. Stewart, Roy T. Anderson, Ridgewood, N. J., and David H. Wilson, Jr., Franklin Township, N. J.

The Jaffrey Manufacturing Company, Trenton, N. J., has been incorporated with a capital of $50,000 to manufacture chemicals. The incorporators are Benjamin D. Phillips, New York; Harry H. Umberger, and L. E. Conover, both of Trenton.

Kellogg Products Company, Inc., Buffalo, N. Y., has been incorporated with a capital of $2,500,000 to manufacture margarines, vegetable oils, soaps, glycerine, chemicals. The incorporators are S. Kellogg, S. Kellogg, Jr., and H. Kellogg, Buffalo.

Keystone Iron & Steel Works, Los Angeles, Cal., has been incorporated with a capital of $500,000. The incorporators are J. E. Geyer, W. S. McGiffert, A. A. Barton, J. P. Loftus and W. F. Allen.

The Koal-Oak Fuel Company, Fresno, Cal., has been incorporated with a capital of $20,000.

The Lincoln Brass Foundry Company, Chester, Pa., has been organized to operate a local brass foundry. F. W. Mathues, Swarthmore, is the principal incorporator.

Lone Pine Mining Company, Ogden, Utah, has been incorporated with a capital of $50,000. The incorporators are J. S. Lewis, G. W. Williams, F. Meisner, J. S. Lewis.

The Loxol Manufacturing Company, Lebanon, Pa., has been incorporated with a capital of $100,000 to manufacture cement, paint, polish, insulators, spark plugs and kindred products. The incorporators are R. B. Locke, L. O. Demers, P. A. Painchaud, T. J. West, Jr., and A. O. Painchaud.

Lutz Chemical Corporation, New York, has been incorporated with a capital of $1,000 to deal in drugs, chemicals, etc. The incorporators are D. A. Lutz, A. Brandt, Emil Tucker.

Manila Copper Mining & Smelting Co., Spokane, Wash., has been incorporated with a capital of $2,000,000. The incorporators are H. Ostrander, H. W. Lefevre, H. J. Neely, L. P. Edge and F. L. Middleton.

The Manufacturers Iron & Steel Company, New Brunswick, N. J., has been incorporated with a capital of $8,000,000 to manufacture iron and steel products. The company will take over and operate the plant of the Neverslip Manufacturing Company, New Brunswick, manufacturer of horseshoes and calks, as well as the plant of the Bryden Horseshoe Company, Catasauqua, Pa. The incorporators are James W. Johnson, William J. McCurdy and Robert C. Nicholas.

The Merigold Electro-Plating Company, Newark, N. J., has been incorporated with a capital of $10 000 to operate a plant at 97 Chestnut Street. The incorporators are John L. Merigold, L. M. and Oliver J. Sizelove.

The Nassau Smelting & Refining Works, 503 West Twenty-ninth Street, New York City, has filed articles of incorporation with capital of $1,000,000 to specialize in the production of materials for foundry use. B. and L. Lowenstein and I. H. Livingston, all of New York, are the incorporators.

National Sulphur Company, Inc., Hornell, N. Y., has been incorporated with a capital of $900,000 to manufacture and refine sulphur and deal in chemicals. The incorporators are C. B. Zabriskie, 119 East Nineteenth Street; H. L. St. John, 270 Riverside Drive, and A. E. Beggs, 876 Carroll Street, Brooklyn.

Navajo-Pacific Copper Company, Delaware, has been incorporated with a capital of $60,600,000 to do general mining, milling, refining and marketing of copper, lead, zinc, gold, silver and all other ores and metals. The incorporators are A. W. Britton, S. B. Howard, L. H. Gunther, H. B. Davis, Jos. F. Curtis, all of New York.

Northern Graphite Corporation, New York City, has been incorporated with a capital of $250,000 to do mining, milling, concentrating ores, etc. The incorporators are G. A. Alonzo, S. Banome, R. Loudon, 2 Rector Street.

The Northwest Magnesite Company, 607 Hutton Building, Spokane, Wash., was incorporated May 10, 1917, with a capital of $1,000,000. The incorporators are B. L. Thane, R. B. Adams, R. S. Talbot and Seabury Merritt. The officers are R. S. Talbot, president; S. F. B. Morse, vice-president; B. L. Thane, consulting engineer; Seabury Merritt, secretary, and D. J. Murphy, treasurer. The company's properties are located about 6 miles from Chewelah, a town on the Great Northern Railroad, situated about 60 miles north of Spokane. Operations were commenced in November, 1916, and about 4000 tons have been shipped. The company will build either a narrow-gage railroad or aerial tramway to the properties. Two rotary kilns, 125 ft. long and 7 ft. 6 in. in diameter are now being installed for calcining the raw magnesite. The capacity of the plant will be about 4500 tons per month.

The Nu Process Gasoline Company, Dover, Del., has been incorporated with a capital of $300,000 to manufacture refined oils. Robert McKnight, F. M. Neeper and A. M. Neeper, all of Pittsburgh, are the incorporators.

Owens & Phillips, Inc., New York, has been incorporated with a capital of $150,000 to deal in chemicals and fire extinguishing compounds. The incorporators are A. R. Latson, Jr., T. E. Smith, E. L. Tamblyn, 424 First Street.

Phenix Sulphur Corp., Delaware, has been incorporated with a capital of $1,000,000 to mine for and dispose of sulphur, gypsum, etc. The incorporators are M. Egner, H. E. Latter, H. M. Robertson, of Wilmington, Del.

The Allen W. Phillips Smelting Company, Attleboro, Mass., has been incorporated with a capital of $50,000. The incorporators are A. W. Phillips, Charles Bloss, Dr. Louis Millet, Thomas G. Sadler.

Quaker-Hill Blue Lead Mines Company, Delaware, has been incorporated with a capital of $3,500,000, to acquire mines and conduct general mining business. The incorporators are H. E. Latter, C. L. Rimlinger, C. M. Egner, Wilmington, Del.

The Quito River Mining & Dredging Company has been incorporated by Robert L. DeGroff and associates in Delaware with capital of $500,000, to operate mining properties. Other incorporators are, S. Woodhull, West Orange, N. J., and Roswell S. Nichols, Westfield, N. J.

Reslow Chemical Company, Newark, N. J., has been incorporated with a capital of $10,000 to manufacture and deal in chemicals and drugs. The incorporators are E. P. Scheck, L. Fisher, L. A. Mills, Montclair.

The Rush Chemical Company, Pittsburgh, Pa., has been incorporated with a capital of $100,000 to manufacture chemicals, etc. The incorporators are Arthur E. Young, B. Ratcliffe, N. N. Hackett, Grant Curry and E. D. Young, all of Pittsburgh.

Schoen-Jackson Company, Pittsburgh, Pa., has been incorporated with a capital of $5000 to deal in iron and steel. The incorporators are A. R. Bassett, W. H. Schoen, M. R. Jackson.

The Superior Iron & Steel Corporation has been incorporated in Dover, Del., with a capital of $3,000,000 to manufacture iron and steel products. The incorporators are Horace G. Eastburn, Artemas Smith and M. E. Doto, all of Wilmington.

Texas Chemical Company, Houston, Tex., has been incorporated with a capital of $100,000. The incorporators are G. F. Howard and E. E. Thomas of Houston and S. Peiser of San Francisco.

Thor Steel Corp., New York City, has been incorporated with a capital of $100,000 to operate steel mills. The incorporators are H. Van Arsdale, Jr., L. A. Watson, C. J. Kulberg.

The Tottenville Copper Company, Inc., Richmond, Staten Island, has been incorporated with a capital of $1,000,000 to operate smelting and refining works. The company has its plant and office on Church Street, Tottenville. B. Lowenstein and I. Livingston are the incorporators.

Tucker-Watney Corporation, New York, has been incorporated with a capital of $100,000 to operate steel mills. The incorporators are C. J. Kulberg, L. A. Watson, H. Van Arsdale.

United States Metals Refining Corporation, Inc., New Jersey, has been incorporated with a capital of $4,000,000 to develop mines. Representative, F. Y. Roberton, 120 Broadway.

The United States Magnesite Company of Spokane has been incorporated to work deposits in the magnesite district of Stevens County. The company has capital stock of

$100,000, and incorporators are Charles P. Oudin and Charles V. Bob. This is the third concern organized for mining magnesite in Stevens County.

The Universal Pipe Line Oil & Producing Co., Delaware, has been incorporated with a capital of $5,000,000 to erect refineries of all kinds. The incorporators are F. D. Buck, M. L. Horth, J. D. Frock.

Universal Ramie Fiber Company, New York, has been incorporated with capital of $10,000,000 to chemically compound and treat greases and growths of fibrous and kindred nature. The incorporators are C. Madden, Hiram Cavannagh, F. H. Coulson, all of New York.

The Utility By-Products Chemical Co., 790 Broad Street, Newark, N. J., has been incorporated with a capital of $50,000 to manufacture chemicals.

Virginia & Ohio Manufacturing Company, Wilmington, Del., has been incorporated with a capital of $50,000. The incorporators are Herbert B. Latter, C. L. Rimlinger, Clement M. Egner, Wilmington.

Vulcan Iron & Steel Company, Paden City, W. Va., has been incorporated with a capital of $300,000. The incorporators are Thomas Watson, George R. Wallace, E. B. Power, S. L. McConaughy, and W. B. Eichleay, all of Pittsburgh, Pa.

Warner-Caldwell Oil Co., Delaware, has been incorporated with a capital of $1,000,000 to mine and bore for petroleum and natural gas. The incorporators are H. E. Latter, C. L. Rimlinger, C. N. Egner.

The Washington Mold Machine & Foundry Company, Washington, Pa., has been incorporated with a capital of $25,000 to operate a local plant. Charles Bromley is the principal incorporator.

Wasson Securities Corporation, New York, has been incorporated with a capital of $362,300 to manufacture iron and steel. The incorporators are M. M. McMahon, L. L. Rohr, A. E. Connelly, 5 Nassau Street.

The Waterloo Refining Co., Delaware, has been incorporated with a capital of $1,250,000 to bore for natural gas, oil, etc., and market and refine the same. The incorporators are M. L. Horty, K. E. Longfield.

Western Producing & Refining Co., Tulsa, Okla., has been incorporated with a capital of $100,000. The incorporators are C. H. Overton, R. K. Hughes, M. J. McNulty.

Wilbur Mining & Milling Co., Dover, Del., has been incorporated with a capital of $200,000 to carry on general mining, milling and refining business. The incorporators are L. B. Phillips, J. B. Bailey.

Wilde & Co., Boston, Mass., has been incorporated with a capital of $25,000. The incorporators are F. R. F. Ellis, Brookline; Charles Perkins, Chicago; W. H. Nash, Boston.

Wildwoods Oil & Sulphur Co., Wilmington, Del., has been incorporated with a capital of $100,000. The incorporators are F. O'Keefe, George G. Steigler, E. E. Wright of Wilmington, Del.

The Williams & Crowell Color Co., Providence, R. I., has been incorporated with a capital of $20,000 to manufacture and deal in dyes and colors. The incorporators are Joseph R. Williams of Pawtucket, H. H. Crowell of Sterling, Conn., and Edwin Knowles of Providence.

Wyoming United Oil Refining Company, Chicago, has been incorporated with a capital of $3,000,000 to bore for oil, produce and dispose of petroleum and its products. Incorporators are R. H. Holton, J. A. Massen, M. M. Hunt, all of Chicago.

Capital Increases, Etc.

The Consolidated Motors Corporation of Philadelphia, a Delaware corporation, has increased its capital from $1,500,000 to $2,500,000 for expansion.

The National Folding Box & Paper Company, 132 Franklin Street, New York, has increased its capital from $1,000,000 to $2,000,000 for expansion.

The Perkins Foundry Company, Amsterdam, N. Y., has increased its caiptal from $20,000 to $50,000 for extensions.

The Crystal Chemical Company, Bronx (New York City), N. Y., has increased its capital from $100,000 to $200,000 for expansion.

The National Fuel Gas Company, 26 Broadway, New York, a New Jersey corporation, has filed notice of increase in capital from $16,000,000 to $32,000,000 for expansion.

The Oliver Chemical Company, Trenton, N. J., with registered office at Perth Amboy, has increased its capital from $10,000 to $125,000 to provide for business extensions.

The New Jersey Paper Tube Company, Nordhoff, N. J., has increased its capital from $25,000 to $90,000 for expansion. Louis S. Coe, president.

The Tennessee Chemical Company has applied for a capital increase from $200,000 to $1,000,000.

The Ohio Steel Products Company, Mineral Ridge, Ohio, has increased its capital stock from $70,000 to $100,000.

The Jackson Furnace & Foundry Company, Jackson, Mich., has increased its capital stock from $20,000 to $70,000.

The Macbeth-Evans Glass Company has increased its capital stock from $2,000,000 to $5,000,000 for extensions and improvements.

States Chemical Company, Chicago, has increased its capital to $25,000 from $2,500.

Construction and Operation

California

SAN FRANCISCO.—The paint and varnish works of the Bass-Hueter Point Company is being enlarged by the addition of a three-story building.

SAN FRANCISCO.—The Pacific Coast Steel Company is contemplating moving from San Francisco to Oakland. The reason given for this is that better transportation facilities are provided in Oakland than in San Francisco. The company is considering constructing a large factory in Oakland to take the place of the one it now occupies.

SAN FRANCISCO.—A large plant for the manufacture of citric acid is planned by a group of big retail druggists. It is planned to use culls of oranges and lemons to manufacture the acid and other basic chemicals. The California Pharmaceutical Association is interested in the project.

SAN FRANCISCO.—The Tulare Mining Company is opening up a dolomite mine about four miles east of Coleville. The company will install kilns and other apparatus for the preparation of calined products.

Connecticut

NEW LONDON.—The Standard Brass & Copper Tube Company will erect an addition to its plant at this place. The company is a subsidiary of the Bridgeport Brass Company.

Idaho

KELLOGG.—The Bunker Hill & Sullivan Mining Company, Frederick W. Bradley, president, will build an electrolytic zinc plant at Kellogg, Idaho; initial capacity 30 tons of ore per day. The lead smelter just being completed by this company will be ready for operation June 1, and at least one stack will be blown in before that date. Coke for the plant will be obtained from the Pacific Improvement Company of Carbonado, Wash., which will start construction of new coke ovens at once. Lime will be obtained from the company's quarries at Ione, Wash.

Indiana

FORT WAYNE.—The Huntington Steel Foundry Company will build a two-story addition to its plant on Condit Street.

Maine

BANGOR.—The Great Northern Paper Company has purchased from the Northern Finance Company water rights, land and other privileges on the Penobscot River. The Great Northern Company plans eventually to build a pulp mill and dam at this place.

Massachusetts

NEW BEDFORD.—The Taunton-New Bedford Copper Company has obtained a permit to build a brick rolling mill and machine shop which will cost $200,000.

Michigan

BAY CITY.—The Roeller Foundry Company has completed an addition to its plant, including a new cupola capable of melting 15 tons of iron per hour. The company makes iron, aluminium and brass castings.

Missouri

ST. LOUIS.—The Standard Oil Company plans an addition to its Woodriver refinery which will cost about $2,000,000.

Montana

ANACONDA.—The Washoe and Great Falls Smelters of the Anaconda Mining Company produced 29,300,000 lb. of copper for the month of April as against 31,300,000 lb. for March. The falling off is due to mine fires, which curtailed production. It is estimated that the yearly production will total 360,000,000 lb.

HELENA.—The American Smelting & Refining Company has taken over under a bond and lease, on a royalty basis, the Sour Dough group of seven mining claims in the Elkhorn District of Jefferson County. Contract provides that the company must take out not less than 100 tons of ore a day. The smelting company desired the ore for the iron silicate contained, to be used for fluxing purposes. At present the fluxing material for the East Helena smelter is shipped from Utah.

Nevada

CARSON CITY.—Benjamin Q. P. Foss of Philadelphia is planning a $75,000 plant near here to produce alcohol from Nevada sagebrush.

New Jersey

BAYONNE.—The Texas Company has filed plans for the erection of a series of one-story additions to its plant at First Avenue and Avenue A. The work will include a new converter house, experimental plants, and asphalt shop, and will cost about $16,000.

CAMDEN.—The Lambert & Todd Machine Company, manufacturer of special machinery, will build a two-story addition to its plant on Arch Street. It is proposed to double the capacity of the plant.

HOBOKEN.—M. J. Kearney is planning to increase the capacity of his copper works at 1206 Clinton Street with the removal of his present New York City shops on Twenty-eighth Street to the local plant.

HOBOKEN.—Fire, May 31, destroyed the two-story plant of the Hibbe Chemical Works, Jefferson Street, with loss estimated at $10,000.

JERSEY CITY.—The Jersey City Cutting & Welding Company, 224 Monmouth Street, has been organized to operate a local plant. John G. Lowe and Christopher Spence are heads of the business.

JERSEY CITY.—The Standard Motor Construction Company, manufacturer of marine and gasoline engines, will build a one-story addition on Whiton Street.

JERSEY CITY.—The Goldschmidt Thermit Company, manufacturer of welding apparatus, is planning for the erection of a one-story addition on Bishop Street to cost about $10,000.

LINDEN.—The Grasselli Chemical Company, whose head office is Cleveland, Ohio, has been granted a permit to erect a new building here. The new structure will cost about $36,000 and will be built of brick and steel construction.

NEWARK.—Fire, on May 26, destroyed a portion of the brass foundry of C. A. Goldsmith, 44 Cutler Street.

NEWARK.—The Verona Chemical Company, Verona and Riverside Avenues, has filed plans for the erection of a one-story addition, about 25 x 45 ft.

NEWARK.—Kraeuter & Company, Inc., 583 Eighteenth Avenue, manufacturer of tools, has filed plans for the erection of a new tool shop and steel works on Nye Avenue, Irvington, to cost $42,000.

NEWARK.—The Block Chemical Works has filed plans for the erection of a one-story addition on Vesey Street.

NEWARK.—The O. W. Young's Oils, Inc., has leased a two-story building at 33 Ross Street, Newark, and will use same for the refining of oils, greases, lubricants, etc.

TRENTON.—The Delion Tire & Rubber Company has awarded contracts for the erection of two new reinforced-concrete additions to its plant on State Street, to cost about $17 000. The structures will be 50 x 110 ft. and 25 x 65 ft.

New York

BUFFALO.—The McDougall Paint Company has leased the property formerly occupied by the Peter A. Voght Manufacturing Company at Water and Norton Streets. After making extensive alterations, the McDougall Paint Company will occupy the property.

BUFFALO.—The Kellogg Products Company, a new $2,500,000 corporation, has purchased the plant formerly occupied by the Buffalo Paint & Varnish Company and the Certainteed Products Company. The directors of the new company are Spencer Kellogg, Jr., Spencer Kellogg, Sr., Howard Kellogg, E. H. Stichel and J. C. Aikman. The company will manufacture margarine, soap, glycerine, edible products and other chemicals. The general offices of the company will be in the Kellogg Building at 98 Delaware Avenue.

CARTHAGE.—The Carthage Sulphite Pulp & Paper Company has purchased additional property for extension of its mills.

North Carolina

NEW BERN.—The New Bern Cotton Oil Mill Company is erecting an addition to its plant on Griffith Street.

Ohio

ALLENDALE.—The Fostoria Pressed Steel Company, incorporated with a capital of $100,000, will make pressed steel parts for the Allen Motor Company. The plant will turn out complete sheet metal products, including enameling and japanning. The company's new plant will have 20,000 sq. ft. of floor space.

HAMILTON.—The plant of the Hamilton Furnace Company at Cokeotto was recently opened after having been closed for almost ten years.

Oregon

PORTLAND.—The Potato Starch Manufacturing Company has been incorporated by Portland capital, headed by J. F. Griffith, and plans the construction of a starch plant near Portland, to be followed later by other plants in the Willamette Valley. The "cull" potatoes will be used in manufacturing the starch, and initial plant will have capacity of 20 tons daily, turning out four tons of starch, besides valuable by-products.

Pennsylvania

PHILADELPHIA.—The Gill Glass Company will erect a three-story, reinforced concrete and brick factory which will cost $200,000.

PHILADELPHIA. — The Philadelphia Paper Manufacturing Company will erect a one-story brick factory building at Nixon north of Fountain Street, costing $75,000.

PHILADELPHIA.—The John Lang Paper Company will erect a five-story addition to the plant here at a cost of $40,000.

Utah

MORONI.—The new sugar plant now under construction here by the People's Sugar Company is expected to be ready to begin operation by October 1. The managers expect to handle 70,000 tons of beets this season. The plant contains the most modern machinery for the production of sugar from beets.

SALT LAKE CITY.—It is reported that the Mineral Products Company is producing 100 to 150 lb. of potash and 300 to 350 lb. of alumina from one ton of rock. A considerable quantity of sulphuric acid is also produced as a by-product.

Washington

ANACORTES.—C. H. Freeman of this city plans immediate development of his molybdenite mining claims near this city, and establishment of concentrate mill. Assays show claims have average run of $50 per ton. Washington Molybdenite Company has been organized, with C. H. Freeman, president, Herman Hohde, vice-president.

NORTHPORT.—The Northport Smelting & Refining Company, of which George S. Bailey is manager, will install building and equipment for the Cottrell process of fume recovery. The estimated cost is $100,000. C. L. Graves is the engineer in charge.

SEATTLE.—Copper ore shipments from Cordova, Alaska, which have been retarded, due to damages to the Copper River & Northwestern Railroad lines by heavy ice jams, will be resumed in the near future. The Tacoma smelter recently received a cargo of 1500 tons of copper ore, which had been mined during the winter and stored in Cordova.

SEATTLE.—The Northwest Lead Company, manufacturers of lead pipe, sheet lead and lead specialties, will remove its plant from Portland to Seattle, where it will occupy a building being remodeled to meet its needs. The plant has a capacity of 25 tons of finished product daily. Much new equipment is to be installed, including a 60-ton sheet lead mill and a lead trap machine weighing 13 tons. Besides above-mentioned products the company will manufacture lead-lined pipe, lead wool for calking water and gas mains, glass lead, sash weights and sinkers.

SEATTLE.—The American Nitrogen Products Company, Securities Building, Seattle, has started survey work on its proposed power plant and nitrogen products plant on the Sauk-Suiattle River, in Snohomish County, 60 miles from Seattle. The company expects to have all outside work completed by early fall, when plans will be prepared in the local office for the buildings and structures, and construction work will start early next spring. The proposed power plant will cost $1,000,000, and ultimate development of the project will represent an investment of several million dollars. The company has a smaller similar plant at La Grande, near Tacoma, which is now producing sodium nitrite. This plant is a preliminary step toward the larger development in Snohomish County. C. F. Graff is president.

SEATTLE.—The Pacific Oils Company, engaged in the manufacture of peanut, soya bean, cocoanut and other vegetable oils, has leased a seven-acre tract on the Duwamish Waterway and will build a factory costing $250,000, according to Herman Meyer, secretary and manager of the concern. Site is leased for thirty-five years.

SPOKANE.—The United Gold Mining Company, according to W. W. Robbins, mine superintendent, plans to replace cyanide by flotation in the dressing of ore in the company's mill at its Oregon properties. A flotation plant with capacity of 75 to 100 tons daily will be installed. Tailings will be stacked and treated by cyanide later.

VALLEY.—The American Mineral Production Company's new buildings at Valley, Wash., are being rapidly pushed to completion. Magnesite is being shipped out of Valley at the rate of four cars daily, about half being crude, the remainder the calcined product. New oil-burning kilns are being constructed and shipments will soon be largely increased.

Wisconsin

MILWAUKEE.—The Valley Steel Company, a newly organized concern, will erect a steel plant at St. Francis, three miles from Milwaukee, located on Lake Michigan. The plant will contain two 60-ton open-hearth furnaces, a 24-in. billet mill and a 10-in. merchant bar mill.

British Columbia

ANYOX, B. C.—The Granby Consolidated Mining, Smelting & Power Company plans to install an experimental plant of 100 tons capacity, using the flotation process, to treat millions of tons of siliceous ore which the company has heretofore not used. If successful, a plant of large capacity will be installed. Operations at the Grand Forks smelters have been interrupted by lack of coke supplies, but the full battery of four furnaces at Anyox are now in operation.

LADYSMITH.—The Ladysmith Smelter, Ladysmith, B. C., is preparing to handle ore shipments and has laid additional trackage at its yards. The smelter itself is practically ready to commence operations, and ore shipments will arrive shortly from various points on the Island and from mines on the British Columbia Coast.

TEXADA ISLAND.—Development of the lime industry on Texada Island, British Columbia, has reached such proportions that the Pacific Lime Company of Vancouver, has taken over a four-masted schooner to carry the product to San Francisco.

TRAIL.—The Consolidated Mining & Smelting Company of Canada, operating a large smelter and appurtenant plants at Trail, B. C., plans to more than double the capacity of its sulphuric acid plant, now producing 12 tons daily. Twenty-four furnaces, each of larger capacity than the furnaces built in the last previous year, will be erected, and extension made to the acid furnace building. The chamber building is also being doubled in size. The initial unit covered an area of 8983 sq. ft., built of tile brick and contained two lead chambers and towers. Increase of capacity is necessitated by the enlarged demand for sulphuric acid in the copper, lead and zinc refineries.

PRINCE RUPERT. — The Molybdenite Mining & Reduction Company, Prince Rupert, B. C., which owns a large deposit of molybdenite near that city, has built an aerial tram mill and concentrator which will treat 150 tons daily.

Manufacturers' Notes

THE BURDETT OXYGEN COMPANY will open an office in Chattanooga, Tenn., at 410 Market Street, which will be in charge of A. W. Collins, field manager of the company. The Burdett Company has a plant in Chattanooga which works in conjunction with Wilson & Co.

THE DRIVER-HARRIS WIRE COMPANY of Harrison, N. J., has filed notice that its name has been changed to Driver-Harris Company. The former name did not comprehensively designate the products of the concern, and while wire makes up an important part of its production, it manufactures largely alloys and pure metals in the form of strip, rods, sheets and castings. This company also manufactures flexible heater cords and wire rope.

THE ASBESTOS PROTECTED METAL COMPANY of Pittsburgh announces the temporary closing of its Atlanta and St. Louis offices. This is due to the fact that J. R. Nichols, Atlanta manager, has entered the Officers' Reserve Corps at Fort McPherson, and F. C. Easterby, St. Louis manager, has entered the Officers' Reserve Corps at Fort Riley, Kan. The home office is in the First National Bank Building, Pittsburgh.

EXPORTS OF ORES FROM PERU TO UNITED STATES.—The following table, from Commerce Reports, shows the quantity and value of certain minerals exported from Peru to the United States during the calendar year 1916:

Product	Quantity	Value
Tungsten, kilos	529,636	$771,041
Vanadium, tons	2,915½	*29,378
Molybdenum, kilos	4,412	8,401
Antimony, kilos	63,038	6,130
Tin bars, tons..........	1	502

*Nominal value.

There are no available official statistics showing the total exportation of these minerals during 1916, but inasmuch as nearly all the minerals were exported to the United States during this period the foregoing table represents practically the total quantity. The tungsten exported is largely of 62 per cent concentrates; molybdenum about 90 per cent, and the antimony 58 per cent.

THE CHARLES A. SCHIEREN COMPANY, New York, manufacturer of Duxbak waterproof and steamproof leather belting, has recently opened branch offices at 72 Congress Street West, Detroit; 18 South Broadway, St. Louis; 475 South Main Street, Memphis; 272 Marietta Street, Atlanta, in addition to those already established at New Orleans, Dallas, Boston, Philadelphia, Pittsburgh, Chicago, Denver and Seattle.

RENNERFELT FURNACES.—Hamilton & Hansell, 17 Battery Place, New York, announce the installation of the following Rennerfelt furnaces: Chili Exploration Co., New York City, 1000 lb. for iron; Central Steel Co., Massillon, Ohio, one-ton for melting ferromanganese.

NEW ASSAYING FIRM IN SALT LAKE CITY.—Under the firm name of Black & Deason, a new firm for assaying and chemical analysis will be opened Monday at 165 South Temple Street. William A. Black was originally an Iowa man, but has spent the last twenty-five years in Salt Lake, being for the last eleven years manager of the R. H. Officer assaying firm, with which he has been identified seventeen years. B. W. Deason was born at Park City, and has spent the last twelve years in Salt Lake, eleven of them being as chief chemist of the R. H. Officer Company.

CONSERVING THE SUPPLY OF TIN PLATE.—At a recent meeting of the Committee on the Conservation of Tin Plate, held at the Bureau of Foreign and Domestic Commerce, Department of Commerce, it was claimed by certain packers of non-perishable products that the recommendation made by the committee to the wholesale grocers "that they forthwith voluntarily suspend or cancel all contracts for delivery of non-perishable food products in tins, made with canners, and fully relieve the latter from all liability thereunder," would result in grocers canceling unfavorable contracts and suspending others. No evidence of any proposed action of this sort was brought to the attention of the committee, which did not, therefore, feel justified in changing the wording of the clause involved. It was thought advisable, however, to state that the committee, in suggesting the option of cancellation or suspension of contracts, did so with the idea that it might in many cases be *mutually agreeable* to suspend rather than cancel contracts and that in such cases, suspension would be quite satisfactory. Another point brought out at the meeting was the question of foreign contracts. It was recommended that contracts affecting the military requirements of our own Government and those of our Allies should be given preferred treatment, but that before making deliveries on such contracts manufacturers should obtain documentary proof of the existence of the contracts, the amount of material required thereon, and satisfactory assurance that shipments would be utilized solely in filling such contracts. While the question of perishability of certain products was discussed, it was the sense of the meeting that the present policy of leaving the decision in all such cases to the Bureau of Chemistry, Department of Agriculture, should be continued.

The Department of Commerce in cooperation with the Department of Agriculture has long been earnestly striving to increase the output of tin cans for food containers. To this end it has endeavored to

increase the supply of tin, to secure the continuous movement of the materials entering into tin cans from the place of production to the place of use, and to facilitate the supply and movement of machinery for producing cans. The department desires in every practicable way to promote the present and permanent prosperity of the tin-can industry. There is no possible doubt of the steady and growing demand for its products.

Tin plate is 98 per cent steel and 2 per cent tin. Steel is the backbone of war, and the mills have not been able to keep all their customers fully supplied at all times. Moreover, abnormal freight demands have made prompt deliveries uncertain. There have also been decreased imports of pig tin, due to decreased production and reduced shipping facilities. It is not surprising, therefore, that the tin-plate makers cannot provide the can manufacturers with sufficient plate to enable them to meet the increase in the demand for cans, which is 25 to 40 per cent greater than it was last year.

It is therefore imperative that the available supply of cans be utilized, in so far as possible, for packing products that can be preserved only in tin, and that substitutes be used for other products wherever practicable. Such containers should be cheaper than tin, so that the ultimate benefit from lower costs may offset the initial expense of the substitution.

The price of glass has steadily risen and has reached a point at which any large extension of its use for food containers is impracticable. At present fiber or paper containers of good quality are being produced in considerable and increasing quantities, and for many purposes are supplanting glass and tin plate. The price of the fiber containers depends upon the size, the quality of the paper-pulp material, the number of treatments with paraffin, and the amount of printed matter on the outside. The commoner types may be obtained at 1.25 to 1.5 cents for the half-pint size, 1.25 to 1.6 cents for the pint size, and 1.5 to 1.65 cents for the quart size. Fiber containers are made in various shapes and sizes adapted to different purposes and may or may not be coated with paraffin, which is chemically inert and is sometimes baked into the paper material. Some of these containers are claimed to be air-tight, proof against leakage, and protected from contamination by the paraffin. Some containers appear to be more nearly air-tight than others of the same style, probably because of better fitting covers. These containers are light in weight, pack readily for shipment, are easily opened, and are used but once.

The demand for "ready-to-eat" foods, such as baked pork and beans, spaghetti, etc., with the simple direction "Heat and serve," represents the largest factor in the increased use of tin cans. These foods must be processed in the containers at or above the temperature of boiling water, and no substitute for tin has been found that satisfactorily meets these conditions. However, a great economy in tin can be effected by home cooking of such products during the present shortage.

Fiber containers are recommended for the distribution by the retailer of many foodstuffs, including milk, cream, buttermilk, ice cream, oysters, syrups, marshmallow creams, dried fruits, preserves, jellies, mincemeat, horseradish, relishes, pickles, deviled ham and chicken, vinegar, dry and prepared mustard, soda water, salads, sauerkraut, and olives.

It is claimed that dry food products such as coffee, tea, alum, baking powder, spices, raisins and prunes may be successfully packed by producers and manufacturers in paper or fiber containers. For some of those products, bags lined with tinfoil have been in successful use for 10 years or more and they form an attractive package that is said to be moisture proof.

Other commodities usually packed in tin could be marketed as well in paper or fiber, with the advantage of lower cost. Among these tobacco occupies a conspicuous position, and other articles are lye, cleansers, soap powders, shoe polishes, metal polishes, soaps and shaving preparations, toilet articles, such as talcum powder, and various dry drugs and chemicals. Paper containers are also suggested for preserved fruits and jellies made at home. Cloth sacks for tobacco and wood for syrups and molasses are also recommended where retail sales can be made in bulk.

For packers of dry products who are opposed to the adoption of fiber containers because of the good-will built up upon the style and shape of a tin container, fiber containers having a tin top and bottom are available. These containers, when labeled, have the appearance of all-tin cans and are almost as serviceable.

Certain types of these containers are now being tested to determine to what extent the claims of their manufacturers as to their general qualities can be substantiated. Manufacturers of substitute containers who wish their products tested should send samples to the Bureau of Standards, Department of Commerce, with full information regarding commodities for which the containers are specially designed, prices and ability to contract for early deliveries. Names and addresses of firms prepared to supply fiber and other containers may be obtained from the Bureau of Foreign and Domestic Commerce or its district or co-operative offices. Co-operation is required between the Government departments, the manufacturers of tin plate and of substitute containers, the packers of foodstuffs, and of other articles commonly put up in tin, and the general public, if the available supply of tin plate is to be limited to strictly necessary uses and if, at the same time, the largest possible quantity of food is to be preserved against the special needs of the coming months.

BEEHIVE COKE PRODUCTION IN 1916.—The production of beehive coke in 1916 was the greatest ever recorded in the United States, and the average value per ton was higher than in any previous year. The official figures for 1916, published by the United States Geological Survey, show that 35,464,224 tons of beehive coke, valued at $95,468,127, were produced last year. The output in 1916 represented an increase over 1915 of 7,955,969 tons, or 29 per cent, in quantity, and $38,522,584, or nearly 68 per cent, in value. The average value per ton of the coal used in making beehive coke in 1916 was $1.26, an increase of 21 cents, or 20 per cent, and the average value of the coke was $2.69, an increase of 62 cents, or 30 per cent. The number of active beehive ovens in 1916 was 65,605, as against 48,985 in 1915, an increase of 16,620. The number of idle ovens was 25,976, as against 44,125 in 1915. Abandoned ovens numbered 2265, of which nearly 1800 were in Pennsylvania and West Virginia. No new establishments and but 104 new beehive ovens at old works were reported to be under construction at the end of 1916, a low record compared with recent years, especially in view of the high prices and steady demand for coke throughout the year. The coke producers evidently recognize the fact that the day of the beehive oven is passing and that after the present abnormal condition is over most coke will be made in by-product ovens. The official figures showing the production of coke in by-product ovens in 1916 have not yet been compiled.

INDUSTRIAL SITES ASSOCIATION.—The Industrial Sites Association of America, 115 Broadway, New York, has been organized for compiling and classifying data concerning the properties, sites, buildings, railroad and water facilities, labor conditions, population, etc., of all towns and cities where manufacturing plants could be advantageously established—a clearing house which would supply manufacturers with complete and verified information free of charge. There are in many parts of the United States any number of cities and towns possessing many superior facilities and natural resources, admirably suited for manufacturing and other industrial purposes. Scarcity of desirable locations is no part of the manufacturers' problem. Their great lack has been a central source of information which would enable them to put their fingers on just what they wanted without traveling from city to city and town to town, spending thousands of dollars and months of valuable time in a fruitless search for factory sites measuring up to their requirements. The officers are E. J. Scriggins, president; E. P. Smith, vice-president, and A. M. Gerow, secretary-treasurer.

LOUISVILLE INDUSTRIAL FOUNDATION.—Louisville, Ky., has formed a million-dollar industrial bureau to assist industrial enterprise of all kinds in that locality. The Foundation has offices in the Columbia Building. The Foundation will render financial assistance to worthy industrial enterprises within the limitations and on the basis indicated in the following charter provision: The Foundation shall not invest more than 10 per cent of its capital in any one concern, nor shall it subscribe to more than 33 1-3 per cent of the total cash paid in capitalization of any one concern: and in considering capitalization, patents, franchises, sales rights, good will and similar items shall not be included. The financial assistance offered by the Foundation is not tendered as an inducement, but rather to provide additional working capital and to that extent assure the success of those manufacturers who may select Louisville as a location because of economic advantages available there.

URGES TRADE AND COMMERCIAL ORGANIZATIONS TO CONTINUE MEETINGS.—President William Fellowes Morgan of the Merchants' Association of New York has addressed a letter to President Wilson on behalf of the Merchants' Association, asking him to discourage the postponement of conventions. Mr. Morgan's letter is as follows:

"It has come to the attention of the Merchants' Association of New York that there is a tendency to forego the holding of conventions and general commercial meetings by business interests of the country because of a desire to practice alleged economy during the war.

"In our judgment this is a false idea of economy, the application of which will be harmful, rather than beneficial, both to the Government and to the Nation's business. Such gatherings, in our judgment, should be encouraged rather than discouraged, because failure to hold them as usual is likely to create a false impression, to stimulate a lack of business confidence and to discourage mutual co-operation which is so necessary under existing circumstances. Conventions and gatherings of different trades and industries afford an exceptional opportunity on the part of business men composing them to study the effect of the war situation upon industries, so that they may be best equipped to serve the needs of the Government and to serve the normal business of the country. Both business and general conventions also afford exceptional opportunities for patriotic gatherings and the fostering of patriotic sentiment.

"We therefore respectfully suggest that, if in your judgment the continuation of such meetings is beneficial, a public utterance by you to that effect would be of great value and would have a marked influence both in stimulating such gatherings and in perpetuating the results flowing therefrom. It seems to us that if ever the citizens of this country should get together, whether in business or general organization meetings, it is during such a period as that through which we are now passing."

Manufacturers' Catalogs

THE DRIVER-HARRIS COMPANY, Harrison, N. J., has issued a new bulletin form of catalog covering its line of products, with the exception of resistance materials, which are covered in its regular resistance catalog. These new bulletins include Monel metal, pure nickel, wire rope, heater cord, cold rolled steel strip, brass, bronze and phosphor bronze wire and "Nichrome" castings.

THE CHALLENGE COMPANY, Batavia, Ill., has issued catalog No. 68, describing wood and steel tanks for all purposes.

THE DE LAVAL STEAM TURBINE CO., Trenton, N. J., has issued a booklet on "Progress in Water Works Pumps."

THE LINK-BELT COMPANY, Chicago, Ill., has issued Book No. 309, 1917, describing the ideal drive for grain elevators.

THE NASH ENGINEERING COMPANY, South Norwalk, Conn., has issued Bulletin No. 7, June 1, 1917, describing hydro-turbine air compressors and vacuum pumps, single-stage type.

THE DURIRON CASTINGS COMPANY, Dayton, Ohio, has issued Bulletin No. 100, April, 1917, describing standard pipe, drainage pipe, fittings, valves, cocks, etc.

THE SMITH GAS ENGINEERING COMPANY, Lexington, Ohio, has issued an attractive booklet, Catalog No. 10, describing its type "MB" gas producer plants for delivering cold, clean gas from bituminous coal, and other types for anthracite coke, charcoal and lignite for power and fuel purposes.

Other New Publications

TEMPERATURE MEASUREMENTS IN BESSEMER AND OPEN-HEARTH PRACTICE. By George K. Burgess. A Department of Commerce publication, No. 91, issued May 8, 1917, by the Bureau of Standards, Washington, D. C.

INDUSTRIAL AND CHEMICAL ENGINEERS is the title of a booklet issued by the Will Corporation, Rochester, N. Y.

THE EMBRITTLING ACTION OF SODIUM HYDROXIDE ON SOFT STEEL. By S. W. Parr, Bulletin No. 94, published by the University of Illinois, Urbana, Ill., at the Engineering Experiment Station.

REPORT ON THE BEET SUGAR INDUSTRY IN THE UNITED STATES. This report was issued on May 24, 1917, by the Federal Trade Commission, Washington, D. C.

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ALPHA NAPHTHYLAMIN
NITRO NAPHTHALIN
1-3-6 ACID
(Naphthylamin Di Sulphonic Acid)

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ORTHO NITRO TOLUOL
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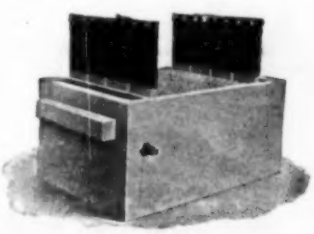
WORKS: CARROLVILLE, WISCONSIN
NEW YORK OFFICE: 120 BROADWAY
RECTOR 7335.
GENERAL OFFICES: FIRST NATIONAL BANK BLDG., MILWAUKEE, WIS.



Type BB Cell

The equivalent of 100 pounds of bleaching powder from 300 pounds of salt

Electrolytic Cells

We supply several sizes, styles and capacities, for various uses, all of which combine the limit of economy and convenience in the continuous production of bleach.

Quick and profitable results are obtained by our method. Write for full description and prices.

The Electro Chemical Company
DAYTON, OHIO, U. S. A.

Capacity	+
Floor Space	—
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Sizes	9

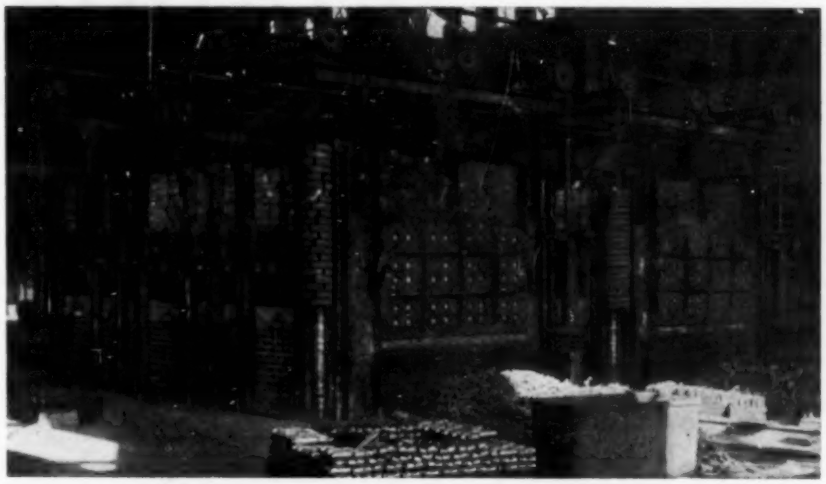
"Vesuvius"

Sulphur Burner

Will *completely* burn any amount of sulphur, depending upon the size of Burner. No sublimation, no dirty fires, no frequent cleaning. All sediment drops to bottom compartment and is easily removed. Determination of quality of gas is readily made without scientific testing instruments. Get specific details.

Valley Iron Works Co.
Appleton, Wis.

INDUSTRIAL HEAT OPERATIONS



Annealing Furnaces, installed at the Plant of the Remington Arms Company, treating 20,000 to 40,000 lbs. of material per charge

CONSULTING, ENGINEERING, DESIGNING AND CONSTRUCTION WORK OF ANY CHARACTER RELATING TO THE APPLICATION OF GAS FOR INDUSTRIAL PURPOSES

THE SURFACE COMBUSTION CO.

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"ROCKWELL" Automatic Annealing Furnaces have proven to hundreds of users their superior efficiency in uniformly heating each piece to an equal temperature for a given length of time. The resulting increased output, with its proportionately decreased fuel and labor costs, greatly reduces production costs.

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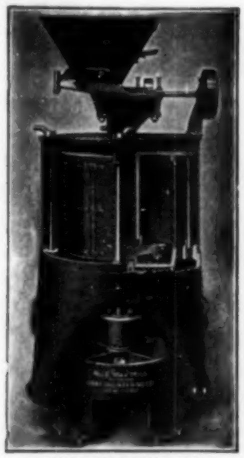

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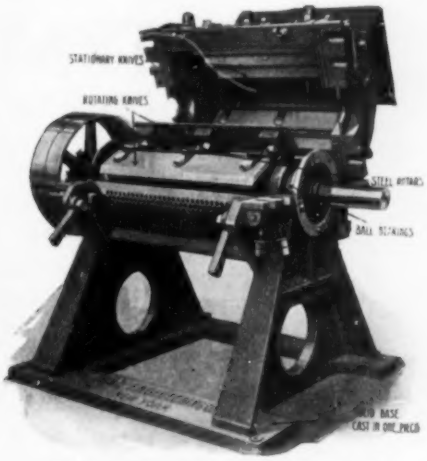

Abbé Rotary Cutter or Shredder

A few ABBÉ Products

ABBÉ ENGINEERING CO.
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are shown here—just a small part of our patented line of 59 sizes and 20 designs of standard pulverizing machinery or machinery *built to order*.

Thousands of satisfied Abbé users in the world today testify to the quality of our patented pulverizing machines. Full data upon request.

No charge for grinding, crushing, cutting or mixing samples and submitting full reports.

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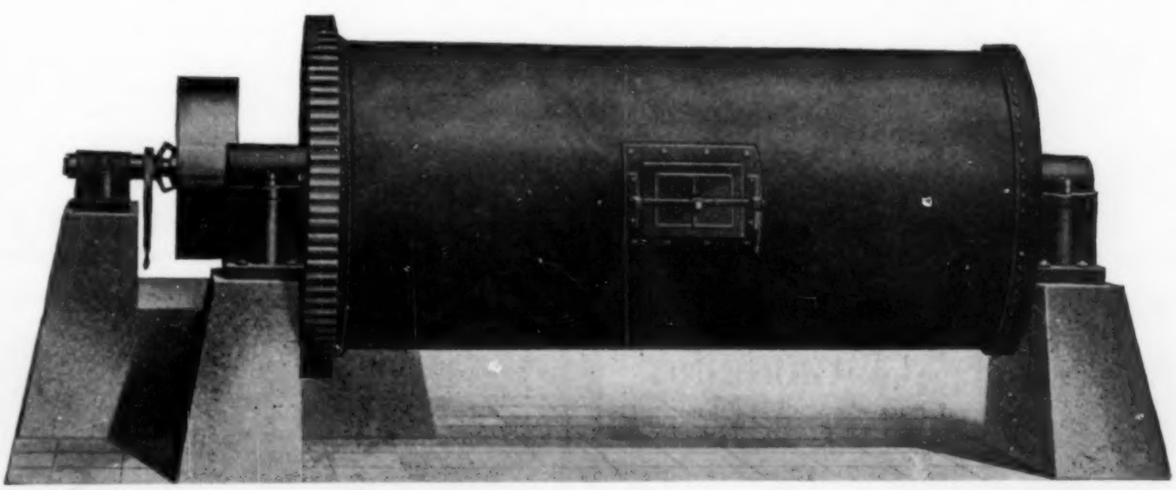
Patterson Continuous Feed and Discharge Tube Mills

All sizes 4'x10' to 6'x30'. All sizes equipt with Patterson Rapid Discharge Device



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The Patterson Foundry Machine Co.

Builders of Satisfactory Machines
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WE ARE FILTRATION ENGINEERS

Untiring attention to details is part of the service you buy with Sperry Filter Presses. It is this expert service, both on the part of engineers and mechanics, which has established the quality character of

SPERRY FILTER PRESSES

At the left is shown a Sperry double-ended 36" Filter Press built to accommodate 100 plates. The picture gives some idea of its rugged strength.

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Send for our new catalog. It is a text book on the subject of Filtration.

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EVERYTHING BUILT IN OUR OWN SHOPS

To American Users of Filter Cloths and Paper Makers' Felts

Save money **by getting your supplies from this mill**

ALL THICKNESSES
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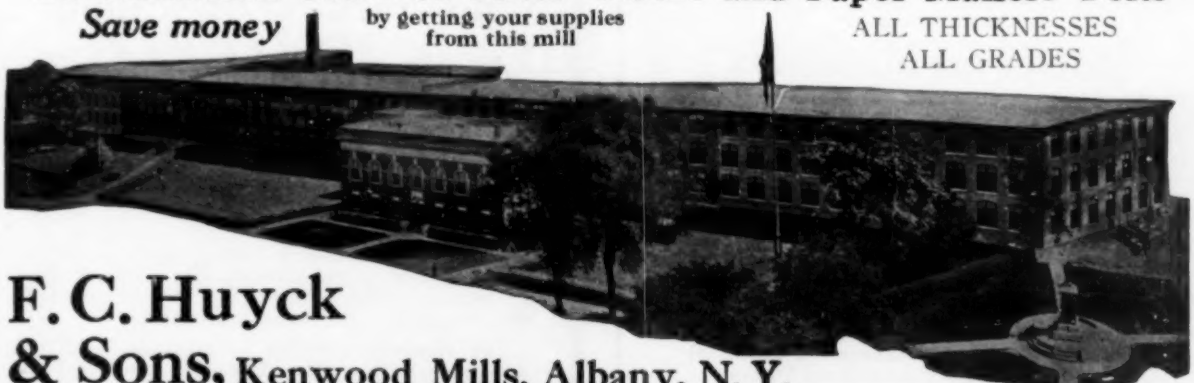

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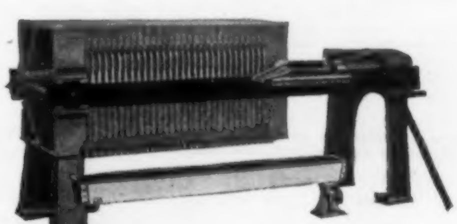

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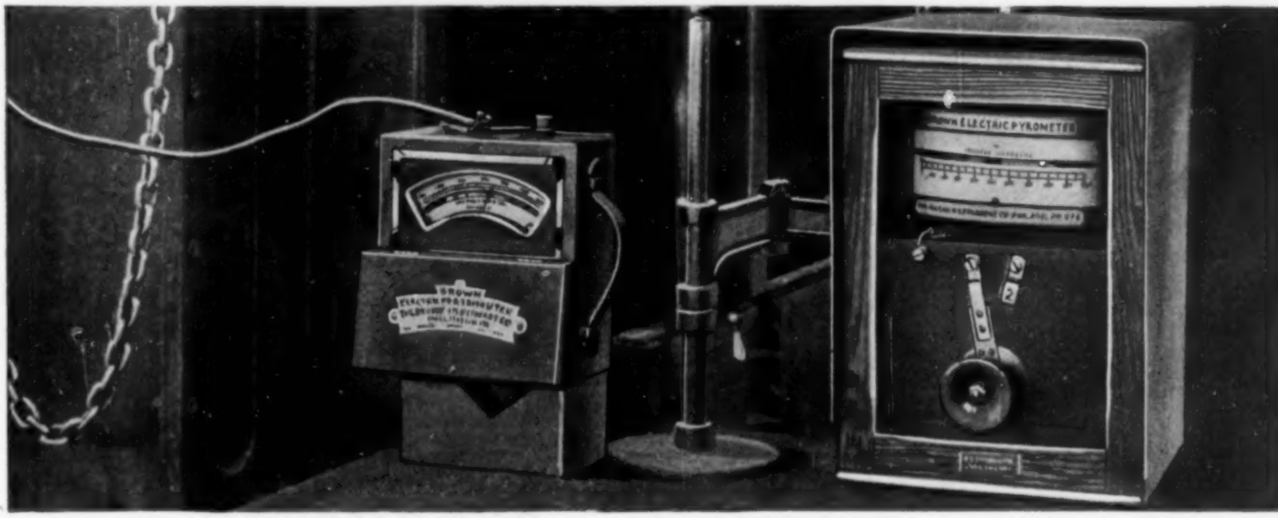

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The above photograph shows a corner of the big Gray & Davis plant and their Brown Pyrometers. Maybe you use a G. & D. lighting system on your car.

If the small parts of an automobile lighting system can be so well heat-treated with Browns that they are little affected by excessive wear and the jolts and jars of rough roads isn't the recommendation of this big firm worth something to you?

There's a plant in your line using a Brown Equipment that will tell you how successful they are. Over 6000 other Brown Boosters are glad to put in a good word.

Write to the Brown Instrument Company, Philadelphia, or one of their offices in New York, Pittsburgh, Detroit or Chicago for full information now.

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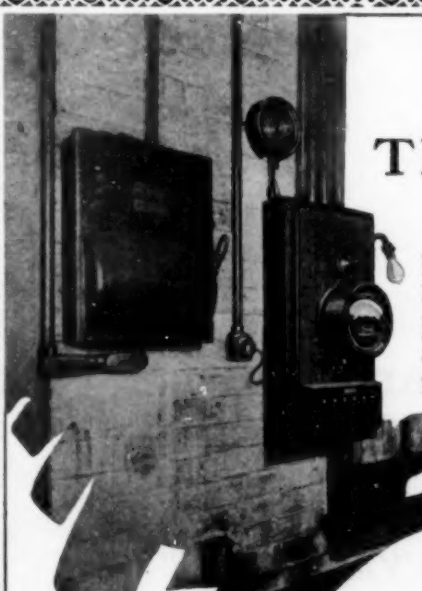

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THE INDESPENSABLE !!

Pyrometry has safeguarded production in all great plants where high temperature is a vital factor. In metallurgical, ceramic and a host of other fields, by pyrometers, precision of results are rendered possible; absolute information available; the records of yesterday for today's guidance; standards of efficiency raised. Proud are we of the part *Tycos* Instruments have played in the upbuilding of great industries, and further to share with our worthy contemporaries the honor accompanying such pyrometer achievements.

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possess the many dependable qualities desired, meeting in abundant measure your expectations. In short the endorsement of *Tycos*; the preference expressed have built up our great factories, still growing—*overwhelming endorsement indeed.*

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20— 4,200 gal. 8′ 8″ dia., 9′ 6″ high.
4—11,740 gal. 8′ 0″ dia., 30′ 0″ long.
4—12,000 gal. 10′ 4″ dia., 19′ 3″ long.

We also have several 4400 gal., 11,350 gal. and 15,000 gal. tanks coming through for delivery in 30, 60 and 90 days.

A large line of second-hand inspected tanks also on hand.

Tank Equipment Co., Inc.
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New Sulphur Burners

3—9-ton Vesuvius Sulphur Burners. Excellent opportunity to secure New Burners at sacrifice.

Dryer

1—Type W-2 Ruggles-Coles-Dryer. Absolutely perfect in all respects. Never used. Bargain.

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61 Broadway New York, N. Y.

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By large business organization located in New York City, the selling agency, of chemicals, dyes, intermediates or pharmaceutical preparations. Our facilities consist of warehouses, large office and sales force, laboratories and chemical staff. We have ample means and can furnish Bradstreet's, Dun's, and banking references. Only those of equal standing and capable of fulfilling any contracts entered into need reply.

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or any material containing Gold, Platinum or Iridium

WE PAY MARKET PRICES

Consignments held subject to your acceptance of our offer.

Goldsmith Bros. Smelting & Refining Co.

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FOR SALE—Four 7-ton "Vesuvius"

BURNERS

Very slightly used, and guaranteed to be in first-class working condition.

We said in our advertisement that this spelled "Opportunity" to some keen manufacturer. It did. You will note that we now have only four for sale.

We are receiving inquiries every day, and if you wish to capitalize this opportunity, address "Opportunity," Box 1164, Met. & Chem. Eng.

Men are snapping up Second Hand Equipment

Now—NOW—NOW is the time to advertise YOUR Equipment—the equipment you want to SELL or the equipment you want to BUY—

Everyone is snapping up the READY DELIVERY stuff. AND DOING IT AT BIG VALUE PRICES.

BEFORE this phenomenal opportunity arrived the Searchlight Section was selling equipment and selling it QUICKLY and PROFITABLY.

But now its value has increased by bounds and leaps—due partly to present never-to-be-duplicated conditions—

And due logically to the Searchlight's position in the minds of the BUYING-POWERS.

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The Searchlight will TELL YOUR STORY for you.

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NOW NOW **NOW**

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New Transformers in Stock

2200 volt primary—single phase—all sizes up to 30 KVA.

4400 and 6600 volt primary—single phase—sizes up to 10 KVA.

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Deliveries on all other sizes 3 to 6 weeks.

Prompt Delivery on All Sizes up to 1500 KVA.

Steam & Electrical Machinery Co.
Bay City, Mich.

TRANSFORMERS

FOR SALE

No.	KVA.	Primary	Volts	Cycles
1	20	220	50-25	25
1	20	220	10-5	25

1—Holtzer-Cabot **GENERATOR** 15 K.W., 50 volts, 1150 R.P.M., type "C," new.

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TANKS

Twenty (20)

Square Wooden Tanks

2" thick, 6' by 6' by 5' deep, lined with two inches of reinforced concrete. In good condition. Cheap. F. S. 1447 (N. Y.)— Met. & Chem. Eng., N. Y. C.

Electrically Lighted Drafting Tables

Three specially constructed adjustable drafting tables with stools

FOR SALE

Glass tops with electric lights placed in reflecting trough beneath the top.

Four different light intensities insure the proper light for any form of tracing.

Very heavy construction and just as good as new.

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Continuous Grinding Tube Mill

not to exceed 16 ft. long; must be Silica-lined with Flint Pebbles for grinding wet material, to pass a screen 150 to 200 mesh per inch. Give full information as to condition, name of manufacturer, and lowest price, with horse power required to operate.
Also two (2) large heavy duty

PEBBLE MILLS

THE OHIO POTTERY CO.,
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For Quick Sale

Scleroscope

In our recent big purchase of the Kennicott Co. we secured one complete Shore Scleroscope, for measuring the hardness of metals.

Write for details and low, quick sale prices.

HARRIS BROTHERS CO.
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WANTED

Rotary Cement OR Lime Kiln

with cooler—size between 110 ft. and 140 ft. length — 7 ft. to 8 ft. in diameter. Must be in good condition and ready for delivery in Three Months. W., 1491 (Mich.), Met. & Chem. Eng., Old Colony Bldg., Chicago.

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Four Hornsby & Akroyd Oil Engines 25 Horse Power Each

First Class Condition

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2—6 x 8

Double Plunger Earthenware Pumps

complete with countershafts, with 9 step cone pulleys. Made especially for pumping chlorine gas.

THE MORSE BROS. MACH'Y & SUPPLY CO.
1732 Wazee St. Denver, Colo.

6000 and 8000 gal. **Car Tanks** Suitable for storage.

Immediate Shipment

Also New Tanks
8000, 10,000, and 12,000 gal.

Better Wire.

Exceptional Bargains in

Rails	Piling
Cars	Tanks
Locomotives	Equipment

Have you a copy of our 20-page bargain bulletin?

ZELNICKER IN ST. LOUIS

WANTED

Wooden Filter Press

of the washing plate and frame type; 100 to 200 square feet of filtering area.

DYE PRODUCTS & CHEMICAL CO.,
187 Pioneer St., Newark, N. J.

FOR SALE: 1—No. A8

Ruggles-Coles Dryer

60 in. diameter, 30-ft. length, complete with Bases and Driving Mechanism.

In fine condition.

COMMERCIAL ACID CO., St. Louis, Mo.

WANTED

One 30 to 40" Centrifugal, Steel curb

Brass or Steel Basket

bottom discharge, belt-driven. Also one 40" Centrifugal, acid resistant, bottom discharge, direct or belt-driven. State manufacturer and full particulars.

PACIFIC COAST BORAX CO.
Bayonne, N. J.

SEARCHLIGHT SECTION

Get your Wants into the Searchlight

ADVERTISING RATES

Under "Positions Wanted," including Salesmen looking for new connections, Evening Work Wanted, etc., undisplayed advertisements cost **three cents a word,** minimum charge 50 cents an insertion, **payable in advance**; less 10% if one payment is made in advance for 4 continuous insertions.

Under "Positions Vacant," including Agents and Agencies Wanted, Representatives Wanted, Salesmen Wanted, Partners Wanted, Business Opportunities, Employment Agencies, and Miscellaneous For Sale, For Rent, and Want ads; also Auction Notices, Receivers' Sales, Machinery and Plants For Sale or Wanted, undisplayed advertisements set solid in one paragraph, cost **five cents a word,** minimum charge $1.50 an insertion.

Machinery advertisements (undisplayed) set with a paragraph for each item, or tabulated, 30 cents a line, minimum 5 lines.

If replies are in care of any of our offices, allow five words for the address.

Advertisements for bids (Proposals) $2.40 an in.

ADVERTISEMENTS IN DISPLAY TYPE

1/16 p. (1 1/8x3 3/8 ins.)	$5.00	1 in. (1x2 1/16 ins.)	$3.00
1/8 p. (2 3/8x3 3/8 ins.)	10.00	4 inches (4x2 1/16 ins.)	11.60
1/4 p. (5x3 3/8 or 2 3/8x7 ins.)	20.00	8 inches (8x2 1/16 ins.)	22.40
1/2 p. (10 1/4x3 3/8 or 5x7 ins.)	40.00	15 inches	40.50

For space to be used within one year, to be divided to suit requirements of advertiser, provided some space is used at least once a month following first insertion:

1 page	$80 a page	9 pages	$65 a page
3 pages	75 a page	12 pages	60 a page
6 pages	70 a page	18 pages	55 a page

In replying to advertisements, do NOT enclose original testimonials, or anything that you may want returned. State your qualifications in as concise and neat a manner as you can and enclose COPIES of testimonials. In machinery ads, use a local name or address if possible so that readers can wire direct and get quick replies.

FOR SALE

For Sale

7 pressure tanks.
4 cast iron pots.
4 crackling presses.
2 filter presses.
The Berg Company, Philadelphia, Pa.

Calcined Aluminum Oxide for Sale

100 tons monthly running 3 per cent silica, and three-tenths of one per cent iron, at 3 cents a pound. F. S., 1513 (Pa.), Met. & Chem. Eng., Phila.

Bauxite for Sale

Bauxite, of best alum grade, 2 cars weekly spot delivery at $9 per ton, Alabama shipping point. F. S., 1515 (Pa.), Met. & Chem. Eng., Phila.

MISCELLANEOUS WANTS

Wanted at Once

For immediate shipment any quantity of battery lead plates, sediment scrap copper and wire, brass and all other grades of scrap material. Write to us today for our prices. National Metal & Rubber Co., 31 India Wharf, Boston, Mass.

BUSINESS OPPORTUNITIES

Bauxite Property for Sale

Bauxite property in Arkansas, 200 acres of high-grade ore on the railroad. B. O., 1514 (Pa.), Met. & Chem. Eng., Phila.

PATENT ATTORNEYS

PATENT ATTORNEY desires to make special arrangement with a corporation to handle all or part of its patent work. Special qualifications for chemical process, product and apparatus matters. Address W. 1489 (N. Y.), Met. & Chem. Eng., N. Y. C.

POSITIONS WANTED

CHEMICAL engineer, graduate, wide general experience in research, metallurgical, manufacturing, physical, electrochemical lines, etc., organic and inorganic, many years chief chemist large laboratories. Only responsible, first-class position considered. Full particulars and references. P. W. 1418 (Ark.) —Met. & Chem. Eng., Chicago.

CHEMICAL and metallurgical engineer, college man, 37, with wide experience in design, construction and operation of ore treatment plants, with some executive and sales experience, thoroughly familiar with iron and steel manufacture and metallurgy, trained chemist, organic and inorganic, will be open for engagement after Aug. 1. Desires position in plant management, research, development, engineering or operation of metallurgical or chemical plant. Present salary $4,000 per year. References furnished. Will consider taking stock in small or new manufacturing plant. P. W. 1502 (Pa.), Met. & Chem. Eng., Philadelphia.

CHEMIST and Mechanical Engineer, five years' experience, desires position affording opportunities for advancement. P. W. 1454 (Ind.)—Met. & Chem. Eng., Chicago.

CHEMIST young man technical graduate, one year experience, good analyst. Wishes position, moderate salary with chance of advancement. P. W., 1479 (N. Y.) Met. & Chem. Eng., N. Y. C.

CHEMIST—Experienced analyst, generally, but especially precious and rare metals, copper, lead, zinc, iron. P. W. 1505 (N. Y.), Met. & Chem. Eng., N. Y. C.

CHEMIST, several years' experience, desires position in research laboratory or plant. Possesses initiative and originality and can handle labor. P. W. 1504 (Pa.), Met. & Chem. Eng., Philadelphia.

CHEMIST, 10 years' experience in general laboratory and plant work, desires a position as chief or operating chemist, at moderate salary. P. W. 1503 (Ind.), Met. & Chem. Eng., Chicago.

CHEMIST, age 30, desires position as executive or manager. Experience; analytical, research, development, executive, plant operator in steel mill, oil refinery, municipal food inspection, acid plant and grinding wheel factory. Very successful, capable, strong personality, graduate U. of Penna.; healthy and hard worker. P. W. 1500 (Pa.), Met. & Chem. Eng., Philadelphia.

Seventeen Years' Experience

Research, Manufacture, Electro-Metallurgical processes, Ferro-Alloys, Electro-Chemical problems, Plant construction and operation. Strictly confidential. P.W. 1456 (Ont.)—Met. & Chem. Eng., Chicago.

POSITIONS WANTED

CHEMIST with thorough analytical and production experience. Object especially advancement. Married. P. W., 1499 (Mich.), Met. & Chem. Eng., Chicago.

CHEMIST, research, analyst. Can reproduce any commercial product. Charles B. Davis, 492 Convent Avenue, N. Y. C.

CHEMIST—Young man at present located, in Detroit, wishes a position as analytical chemist in Chicago. Six years' experience in ores and in materials used in automobile manufacture. Able to install a laboratory in iron or brass foundry. Good references furnished, and can report on short notice. P. W. 1495 (Mich.), Met. & Chem. Eng., Chicago.

CHEMISTRY, young man, 22, inexperienced, with knowledge and training in organic and analytical chemistry, desires position as beginner. P. W., 1511 (N. Y.), Met. & Chem. Eng., N. Y. C.

CHIEF chemist, 12 years' experience in metallurgical analysis, including electric furnace production of ferro-manganese and steel. Well qualified and highest references. P. W. 1496 (Ala.), Met. & Chem. Eng., Philadelphia.

CORNELL University graduate, with about three years' general analytical experience, wants position in industrial research chemistry. Address Miss Brown, 251 W. 25th St., New York City.

ELECTROMETALLURGICAL engineer, technical graduate, wide experience in smelting and electrolytic refining of copper, desires correspondence with firm requiring a man with executive ability for position of responsibility. Salary $2,500. P. W. 1433 (N. J.)—Met. & Chem. Eng., N. Y. C.

ELECTROMETALLURGIST, technical graduate, married, three years' experience as chief chemist and production engineer on electric smelting and refining of ferro alloys. P. W. 1494 (Pa.), Met. & Chem. Eng., Philadelphia.

GRADUATE chemist experienced in iron, steel and ferro-alloy analysis, design and operation of electric furnace ferrosilicon plant. Now under contract, open for engagement Sept. 1. P. W. 1483 (N. Y.), Met. & Chem. Eng., N. Y. C.

SEARCHLIGHT SECTION

POSITIONS WANTED

GRADUATE chemist (Ph.B.), formerly with large manufacturing concern, familiar with testing of raw materials and general investigation work—glass, refractory materials, graphite products, oils, paints, lubricants, and commercial organic analysis—seeks position in New York City or immediate vicinity at moderate salary. P. W. 1493 (N. Y.), Met. & Chem. Eng., N. Y. C.

METALLURGICAL chemist, wide experience in the manufacture and analysis of non-ferrous metals, brasses, babbitts, etc., and the concentration, smelting and refining of secondary metals. P. W. 1484 (Ill.), Met. & Chem. Eng., Chicago.

UNIVERSITY graduate (1917) in chemical engineering desires a position. Salary $70 a month. P. W., 1512 (N. Y.), Met. & Chem. Eng., N. Y. C.

YOUNG man, recent graduate in chemistry, from Cooper Union, desires a position as assistant chemist in the laboratory of an established chemical concern. Willing to start at a moderate salary. P. W. 1497 (N. Y.), Met. & Chem. Eng., N. Y. C.

POSITIONS VACANT

A FIRST class electric smelting and reduction company in the Middle West wants a metallurgist thoroughly familiar with iron, steel and alloys, possibly Ph. D., to manage the plant. Liberal salary and permanent position for right man. Applications handled in strict confidence. Address P. 1431 (Ill.) —Met. & Chem. Eng., Chicago.

A man with personality, some business, and chemical or chemical engineering experience is needed for a work that requires **sales ability.** To the right man a splendid opportunity is open. State qualifications, references, salary expected.

P., 1507 (N. Y.), Met. & Chem., N. Y. C.

We Buy

ideas—and develop and market them on a royalty basis.

GIBB INSTRUMENT CO.
5716 Euclid Ave. Cleveland, Ohio

POSITIONS VACANT

CAPABLE party wanted to superintend manganese mining operations and shipment of product. Have large deposits opened up, both metallic and dioxide manganese. Address Manganese P. 1445 (Ore.)—Met. & Chem. Eng., Chicago.

EXPERIENCED man wanted to erect and operate plant to manufacture electrodes for electric furnaces. Address Electrode, P. 1446 (Ore.)—Met. & Chem. Eng., Chicago.

EXPERIENCED man wanted to manage an electrolytic, caustic, and chloride of lime plant. Good chance of advancement. State age, experience and salary required. P. 1485 (N. C.), Met. & Chem. Eng., Philadelphia.

ELECTRODES—Experienced man to go abroad as master foreman in electrode factory. Give age, experience, nationality, and wages expected. P. 1510 (N. Y.), Met. & Chem. Eng., N. Y. C.

METALLURGIST — Firm making steel automobile parts, one of the largest in its field, needs a competent metallurgist. Familiarity with modern chemical and metallographical control is essential. Must have sufficient initiative to lay out proper methods and the necessary personality to see that those methods are followed. Address P. 1488 (Pa.), Met. & Chem. Eng., Philadelphia.

The Searchlight Advertising in This Paper

is read by men whose success depends upon thorough knowledge of means to an end—whether it be the securing of a good second-hand piece of apparatus at a moderate price, an expert chemical or metallurgical engineer or superintendent, or the services of a firm of engineers for designing a large modern plant.

The Best Proof

of this is the regularity with which such advertisements are carried—and the variety of this journal's Want ads. Without a constant and appreciable *demand* for such machinery or services, by its readers, the market-place which these advertisements represent could not exist for any length of time.

Are *you* using the Searchlight Section?

Metallurgical and Chemical Engineering
239 W. 39th St., New York

AGENTS AND SALESMEN

Engineering Salesman Wants Position

Position wanted by man of forty, as engineering salesman on new and difficult propositions. Experience wide and detailed, acquainted with banking and engineering circles. A1 technical business training. Salary not prime object. Friends say he has excess of assurance. Address S. 1444 (N. Y.)—Met. & Chem. Eng., N. Y. C.

EMPLOYMENT AGENCIES

Correspondence Service

The undersigned provides a confidential service designed to locate openings through correspondence, for men earning not less than $2,500 and up to $25,000; all lines. Not an employment agency but a constructive, initiative service, covering individual negotiations. Established 1910. Complete privacy assured; present connections in no way jeopardized. Send name and address only for explanatory details. R. W. Bixby, D1, Niagara Square, Buffalo, N. Y.

CHEMISTS — EMPLOYERS

Chemists seeking suitable positions and employers seeking suitable chemists should write Julian M. Blair, Secretary,

THE CHEMISTS' EMPLOYMENT BUREAU
Nashville, Tenn.

No charge to employers. No initial expense to chemists. Foreign applications solicited.

WANTED

—

Factory Manager

experienced in the rubber industry, especially in compounds and compounding $5,000

Research Chemist

to manage laboratory doing research work on aluminum $2,500

Foremen

Several department foremen experienced on mechanical rubber goods and hydraulic leather packing. Approx. $2,000

National Employment Exchange

Officers and Directors:
Otto T. Bannard, President
John R. MacArthur, Vice-President
Francis L. Hine, Treasurer
Eugene H. Outerbridge, Secretary
Robert W. DeForest — Newcomb Carlton
L. F. Loree — Arthur Williams
G. S. Anthony, General Manager

30 Church Street, New York City

What Advertisers Offer to Readers

Classified Index of Products Advertised in This Issue by Representative Manufacturers and Dealers

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Prest-O-Lite Co.
Acid Concentration Apparatus
Chemical Construction Co.
Duriron Castings Co.
International Glass Co., The
Kalbperry Corp., The
Pratt Eng. & Machine Co.
Thermal Syndicate, Ltd., The
Acid Distillation Apparatus
Buffalo Foundry & Machine Co.
Fulton Foundry Co.
Thermal Syndicate, Ltd., The
Acid Eggs, Cast Iron
Bethlehem Fdry. & Mach. Co.
Buffalo Fdry. & Mach. Co.
Devine Co., J. P.
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Fulton Foundry Co.
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Eimer & Amend.
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Scientific Materials Co.
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Asbestos Protected Metal Co.
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Bausch & Lomb Opt. Co.
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Braun-Knecht-Heinmann Co.
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Abbé Engineering Co.
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Nash Engineering Co.
Blowers, Flotation
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Brick and Clay, Fire
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Foote Mineral Co.
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Laclede-Christy Clay Products Co.
Mine & Smelter Supply Co.
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Brown Hoisting Machinery Co.
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Union Carbide Co.
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Gaertner, Wm., & Co.
Palo Co.
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Schaeffer & Budenburg Mfg. Co.
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National Carbon Co.
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Easton Car & Construction Co.
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Duriron Castings Co.
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Buffalo Fdry. & Mach. Co.
Duriron Castings Co.
Jacoby, Henry E.
Lunkenheimer Co., The.
Moore, Sam'l L., & Son
Pacific Foundry Co.
Sperry, D. R., & Co.
Valley Iron Works.
Castings, Iron
American Cast Iron Pipe Co.
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Lunkenheimer Co., The.
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Castings, Monel Metal
Supplee-Biddle Hdwe. Co.
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Caustic Soda and Chlorine
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Electrolytic Engineering Corp.
Electron Chemical Co.
Warner Chemical Co.
Causticizing Apparatus
Dorr Co., The
Scott, Ernest, & Co.
Zaremba Co.
Cement, Acid Proof
Anti-Hydro Waterproofing Co.
Cement Furnace
Quigley Furnace Specialties Co.
Centrifuges
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Sharples Specialty Co.
Tolhurst Machine Works
Wayte, W. J., Inc.
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Eimer & Amend.
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Laboratory Apparatus Co., Pittsburgh.
Marden, Orth & Hastings, Inc.
Merck & Co.
Mine & Smelter Supply Co., The.
Newport Chemical Works
Roessler & Hasslacher Chemical Co., The.
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Schaar & Co.
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Compressors, Air or Gas
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Nash Engineering Co.
Concentrating Tables
Mine & Smelter Supply Co., The.
Concrete Hardening Compound (Liquid)
Anti-Hydro Waterproofing Co.
Condensers, Barmometric, Surface or Jet
Buffalo Fdry. & Mach. Co.
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Devine Co., J. P.
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General Electric Co.
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Ott, George F., Co.
Roos', August, Son.
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Guernsey Earthenware Co.
Laboratory Supply Co.
Mine & Smelter Supply Co., The.
Thermal Syndicate, Ltd., The.
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Acheson Graphite Co.
Bartley, Jonathan, Crucible Co.
Crucibles and Dishes, Platinum
Baker & Co., Inc.
Bishop, J., & Co., Platinum Wks.
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See Machinery, Crushing, Grinding and Pulverizing.
Crushers, Grdrs. Pulv., Lab.
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Pfaudler Company.
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Caldwell, W. E., Co.
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What Advertisers Offer to Readers

Classified Index of Products Advertised in This Issue by Representative Manufacturers and Dealers

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Pratt Eng. & Machine Co.
Stuart & Peterson Co.
Swenson Evaporator Co.
Werner & Pfleiderer Co.

Distilling Machy. and Apparatus
Aetna Steel Products Co.
Badger, E. B., & Sons Co.
Blair, Campbell & McLean, Ltd.
Detroit Heating & Lighting Co.
Devine Co., J. P.
Duriron Castings Co.
Elyria Enameled Products Co.
Fulton Foundry Co.
Isbell-Porter Co.
Koven, L. O., & Bro.
Lummus, The W. E., Co.
Mott, J. L., Iron Works
Ott, George F., Co.
Pfaudler Co., The.
Roos', August, Son.
Scott, Ernest, & Co.
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Thomas Co., Arthur H.
Stuart & Peterson Co.
Swenson Evaporator Co.
Werner & Pfleiderer Co.
Zaremba Co.

Door Screens
Codd, E. J. Co.

Drop Forge Fittings
Vogt, Henry, Machine Co.

Drums, Steel
Detroit Range Boiler Co.

Dry Blast Plants
Carrier Engineering Corporation.

Dry Cell Filler
Acheson Graphite Co.

Dryers, Centrifugal
Schaum & Uhlinger, Inc.
Sharples Specialty Co.
Tolhurst Mach. Works.

Dryers, Vacuum
Aetna Steel Products Co.
Buffalo Foundry & Machine Co.
Devine, J. P., Co.
Jacoby, Hy. E.
Pratt Eng. & Machine Co.
Scott, Ernest, & Co.
Sowers Mfg. Co.
Werner & Pfleiderer Co.

Drying Mach. & Apparatus
American Blower Co.
American Process Co.
Buffalo Forge Co.
Buffalo Foundry & Machine Co.
Clarage Fan Co.
Devine Co., J. P.
Gordon Engineering Corp.
Koven, L. O., & Bro.
Manitowoc Engineering Works.
Redfield, R. S.
Ruggles-Coles Eng. Co.
Scott, Ernest, & Co.
Stearns-Roger Mfg. Co.
Swenson Evaporator Co.
Vulcan Iron Works.
Werner & Pfleiderer Co.

Dust Collecting Systems & Engineers
Clark Dust Collecting Co.
Knickerbocker Co.
Pratt Eng. & Machine Co.
Raymond Bros. Imp. Pul. Co.
U. S. Blow Pipe & Dust Collecting Co.
Williams Patent Crusher & Pulveriser Co.
York Corrugating Co.

Dyes and Dyestuffs
Marden, Orth & Hastings, Inc.

Dynamos, Electroplating
See Electroplating Dynamos; Supplies.

Dynamos and Motors
Bogue, C. J., Elect. Co.
General Electric Co.
Jantz & Leist Elect. Co.
Lincoln Electric Co.
Westinghouse Electric & Mfg. Co.

Electric Cranes
See Cranes

Electric Furnace Accessories
Volta Mfg. Co., The.

Electric Furnaces
See Furnaces, Electric

Electric Furnaces, Lab'y.
See Furnaces, Elec. Lab'y.

Electrical Supplies
General Electric Co.

Electrical Testing Sets
American Transformer Co.
Thordarson Electric Mfg. Co.

Electrode Holders
Volta Mfg. Co., The.

Electrodes, Carbon
Acheson Graphite Co.
National Carbon Co.

Electrodes, Graphite
Acheson Graphite Co.

Electrodes, Platinum
American Platinum Works.
Baker & Co., Inc.
Bishop, J. & Co., Platinum Works.

Electrolytic Cells
Electro Chemical Company, The.
Electrolytic Eng. Corp.
Electron Chemical Co.
Warner Chemical Co.

Electroplating Dynamos; Supplies
Bogue, C. J., Elect. Co.
Jantz & Leist Elect. Co.

Electrolytic Salts
Roessler & Hasslacher Chem. Co.

Elevating and Conveying Machinery
See Machinery, Conveying and Elevating.

Enameled Apparatus Acid Resisting
Elyria Enameled Apparatus Co.
Mott, J. L., Iron Works
Pfaudler Co., The.
Stearns-Roger Mfg. Co.
Stuart & Peterson Co.

Engineers, Chemical, Consulting, Analytical, Industrial
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Kalbperry Corp., The.
Little, Arthur D., Inc.
Powdered Coal Eng. & Equipment Co.
Pratt Eng. & Machine Co.
Southwestern Engineering Co.
Volta Mfg. Co., The.
Wayte W. J., Inc.
Williams Apparatus Company.

Engineers, Combustion
Improved Equipment Co.
Surface Combustion Co.

Engineers' Construction
Chemical Construction Co.
Foundation Co.
Green, Samuel M., Co.
Guarantee Construction Co.
Southwestern Engineering Co.

Engineers, Furnace
Hagan, Geo. J., Co.
Rockwell, W. S., Co.
Russell Engineering Company.
Surface Combustion Co.

Engineers, Pyrometric
Holz, Herman A.

Engines, Hoisting and Hauling
Vulcan Iron Works.

Equipment (2nd Hand)
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Evaporating Dishes
Guernsey Earthenware Co.
Knight, M. A.
Thermal Syndicate, Ltd., The.
U. S. Stoneware Co.

Evaporators
Aetna Steel Products Co.
Allbright-Nell Co., The.
Badger, E. B., & Sons, Co.
Blair, Campbell & McLean, Ltd.
Buffalo Fdry. & Mach. Co.
Devine, J. P., Co.
Jacoby, Henry E.
Kestner Evaporator Co.
Koven, L. O., & Bro.
Lummus, The W. E., Co.
Ott, Geo. F., Co.
Pfaudler Co., The.
Pratt Eng. & Machine Co.
Redfield, R. S.
Roos', August, Son.
Scott, Ernest, & Co.
Sowers Manufacturing Co.
Swenson Evaporator Co.
Werner & Pfleiderer Co.
Zaremba Co.

Extracts
Marden, Orth & Hastings, Inc.

Extractors
Badger, E. B., & Sons Co.
Blair, Campbell & McLean, Ltd.
Koven, L. O., & Bro.
Lummus, The W. E. Co.
Ott, Geo. F., Co.

Extractors, Centrifugal
Schaum & Uhlinger, Inc.
Sharples Specialty Co.
Tolhurst Machine Works

Fans
Buffalo Forge Co.
Clarage Fan Co.
General Electric Co.
Pratt Eng. & Machine Co.
Raymond Bros. Impact Pulv. Co.
Stearns-Roger Mfg. Co.
Sturtevant Co., B. F.
Williams Patent Crusher & Pulv. Co.

Fans, Stoneware, Acid Proof
General Ceramics Co.
Knight, M. A.
U. S. Stoneware Co.

Faucets, Stoneware, Acid Proof
See Stoneware, Chemical.

Feeders
Stephens-Adamson Mfg. Co.
Webster M'f'g. Co., The.

Ferro-Alloys
Goldschmidt Thermit Co.
Lavino, E. J., & Co.
Leavitt, C. W., & Co.
Standard Alloys Co.
Titanium Alloy Mfg. Co.

Ferro-carbon—Titanium
See Titanium

Fire Extinguishers
American La France Fire Engine Co.

Filter Cloth
Huyck, F. C., & Sons

Filter Paper
H. Reeve Angel & Co.
Eimer & Amend
Laboratory Supply Co., The

Filter, Porous Porcelain
Herold China & Pottery Co.

Filter Presses
Allbright-Nell Co., The
Colorado Iron Works Co.
Industrial Filtration Corporation
Jacoby, Henry E.
Johnson, John, Co.
Kelly Filter Press Co.
Koven, L. O., & Bro.
Lungwitz, E. E.
Oliver Continuous Filter Co.
Patterson Fdry. & Mach. Co.
Perrin, Wm. R., & Co.
Redfield, R. S.
Shriver, T., & Co.
Sperry, D. R., & Co.
Werner & Pfleiderer Co.

Filter Press Distill'y Grains
Swenson Evaporator Co.

Filtering Media
Celite Products Co.
General Filtration Co., Inc.

Filters, Rotary Continuous
Colorado Iron Works Co.
Industrial Filtration Corp.
Oliver Continuous Filter Co.
Southwestern Engineering Co.

Filters, Suction, Stoneware, Acid Proof
General Ceramics Co.
Knight, M. A.

Filters, Vacuum
General Filtration Co., Inc.
Stevens-Alysworth Co.

Fire Brick and Clay
See Brick and Clay, Fire

Fireproof Building Materials
Asbestos Protected Metal Co.

Floors & Pits, Acid Resisting
Anti-Hydro Waterproofing Co.

Flotation Apparatus
Braun Corporation, The.
Braun-Knecht-Heinmann Co.
Colorado Iron Works
Pensacola Tar & Turpentine Co.
Southwestern Eng. Co.

Flotation Oil
Pensacola Tar & Turpentine Co.
Standard Chemical Co.

Fluorspar
Lavino, E. J., & Co.

Foundry Supplies
Electric Smelting & Alum. Co.

Furnace Cement
See Cement, Furnace

Furnace Engineers
See Engineers, Furnace

Furnace Facings & Linings
Acheson Graphite Co.
Celite Products Co.
Laclede-Christy Clay Products Co.
Quigley Furnace Specialties Co.

Furnace Hoists
Brown Hoisting Machinery Co.

Furnaces, Assay
Braun Corporation, The.
Braun-Knecht-Heinmann Co.
Mine & Smelter Supply Co.

Furnaces, Chloridizing and Sulphating
Wedge Mechanical Furnace Co.

Furnaces, Cupola, Foundry
Worthington Pump & Mach. Corp.

Furnaces, Electric
Hamilton & Hansell
Leavitt, C. W., & Co.

Furnaces, Electric, Lab'y.
Brown Instrument Co.
Electric Htg. Apparatus Co.
Engelhard, Chas.
Hoskins Mfg. Co.

Furnaces, Gas
Surface Combustion Co.

Furnaces, Heat Treating
Electric Htg. Apparatus Co.
Engelhard, Chas.
Hagan, Geo. J., Co.
Hoskins Mfg. Co.
Rockwell, W. S., Co.
Russell Engineering Company.
Surface Combustion Co.
Wedge Mechanical Furnace Co.

Furnaces, Melting:
Oil, Gas or Powdered Coal
Hagan, Geo. J., Co.
Rockwell, W. S., Co.
Russell Engineering Company.
Surface Combustion Co.

Furnaces, Muffle
Electric Htg. Apparatus Co.
Hoskins Mfg. Co.
Improved Equipment Co.
Russell Engineering Company.
Wedge Mechanical Furnace Co.

Furnaces, Roasting and Smelting
Colorado Iron Works Co.
General Chemical Co., The
Pacific Foundry Co.
Pratt Eng. & Machine Co.
Russell Engineering Company.
Traylor Eng. & Mfg. Co.
Wedge Mechanical Furnace Co.

Furnaces, Sulphur
General Chemical Co., The
Pacific Foundry Co.
Pratt Eng. & Machine Co.
Schutte & Koerting Co.
Wedge Mechanical Furnace Co.

Fused Silica
Thermal Syndicate, Ltd., The.

Gas Furnaces
See Furnaces, Gas

Gas Producers
Chapman Eng. Co.
Hagan, Geo. J., Co.
Improved Equipment Co.
Morgan Const. Co.
Smith Gas Engineering Co., The

Gas Pumps and Exhausters
See Pumps, Gas, Liquid, Vacuum

Gas Scrubbers and Washers
Buffalo Forge Co.

Gauges, Recording, Indicating, Draft, Pressure
Bristol Co., The
Brown Instrument Co.
Foxboro Co.
Schaeffer & Budenburg Mfg. Co.
Taylor Instrument Companies.
Thwing Instrument Co.

Gears
Caldwell, H. W., & Son Co.

Gears, Silent
General Electric Co.
Pratt Eng. & Machine Co.

Generators:
See Dynamos and Motors

Glass Blowing
International Glass Co.
Laboratory Supply Co.
Palo Co.
Scientific Materials Co.

Glassware, Chemical
Flasks, Beakers, Crystallizing Dishes, Hydrometer Jars, Petri Dishes, etc.
Eberbach & Son Co., Inc.
Eimer & Amend
Fry Co., H. C.
Griebel Instrument Co.
International Glass Co., The
Laboratory Supply Co., The
Mine & Smelter Supply Co., The

Glazing Construction
Asbestos Protected Metal Co.

Graphite
Acheson Graphite Co.

Grinders
See Machinery, Crushing, Grinding and Pulverizing

Hardness Testers
Holz, Herman A.

Heaters, Feed Water
Braemer Air Conditioning Co.

Heating Apparatus and Systems
American Blower Co.
Braemer Air Conditioning Co.
Buffalo Forge Co.
Clarage Fan Co.
Ruggles-Coles Eng. Co.
Sarco Co., Inc.

Hoists
Brown Hoisting Machinery Co.

Hydrometers
Griebel Instrument Co.
Taylor Instrument Companies.

Hydrogen Plants
Improved Equipment Co.

Hypochlorite Cells
Electro Chemical Co.

Instruments, Electrical and Testing
Bristol Co., The
Brown Instrument Co.
Eimer & Amend
General Electric Co.
Hoskins Mfg. Co.
Leeds & Northrup Co., The
Pyrolectric Instrument Co.
Schaeffer & Budenburg Mfg. Co.
Shore Instrument Co.
Slocum, Avram & Slocum Laboratories, Inc.
Stupakoff Laboratories
Thwing Instrument Co.
Westinghouse Electric & Mfg. Co.

Insulating Material, Heat
Armstrong Cork & Insulation Co.
Celite Products Co.

What Advertisers Offer to Readers

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Intermediates
Marden, Orth & Hastings, Inc.
Newport Chemical Works, Inc.
Iron and Steel, Corrugated
Asbestos Protected Metal Co.
Jigs
Worthington Pump & Mach. Corp.
Kettles, Cast Iron Acid Proof
Bethlehem Fdry. & Mach. Co.
Buffalo Fdry. & Machine Co.
Devine, J. P., Co.
Duriron Castings Co.
Fulton Foundry Co.
Pacific Foundry Co.
Pratt Eng. & Machine Co.
Sowers Manufacturing Co.
Stevens-Aylsworth Company.
U. S. Cast Iron Pipe & Fdy. Co.
Werner & Pfleiderer Co.
Kettles, Enameled, Acid Proof
Elyria Enameled Products Co.
Mott, J. L., Iron Works
Pfaudler Co.
Stuart & Peterson Co.
Kettles, Steam Jacketed
Aetna Steel Products Co.
Buffalo Fdy. & Machine Co.
Day, The J. H., Co.
Detroit Heating & Lighting Co.
Devine Co., J. P.
Duriron Castings Co.
Elyria Enameled Products Co.
Hand, E. L., & Co.
Koven, L. O., & Bro.
Mott, J. L., Iron Works.
Ott, George F., Co.
Pfaudler Company, The.
Stevens-Aylsworth Co.
Stuart & Peterson Co.
Werner & Pfleiderer Co.
Kettles, Stoneware, Acid Proof
See Stoneware Chemical.
Kiln, Lime
Improved Equipment Co.
Vulcan Iron Works.
Kiln, Rotary & Nodulizing
American Process Co.
Ruggles-Coles Eng. Co.
Vulcan Iron Works.
Laboratories, Chemical and Physical
Lunkenheimer Co., The.
Laboratory Apparatus and Supplies
Bausch & Lomb Opt. Co.
Braun Corporation, The.
Braun-Knecht-Heinmann Co.
Buffalo Dental Mfg. Co.
Daigger, A., & Co.
Eimer & Amend.
Emerson Apparatus Co.
Gaertner, Wm., & Co.
Guernsey Earthenware Co.
Hoskins Mfg. Co.
International Glass Co.
Laboratory Apparatus Co., Pittsburgh.
Laboratory Supply Co., The.
Leeds & Northrup.
Mine & Smelter Supply Co., The.
Multi-Metal Separating Screen Co.
Palo Co.
Pyrolectric Instrument Co.
Sargent, E. H., & Co.
Schaar & Co.
Scientific Materials Co.
Thomas Co., Arthur H.
Laboratory Ware, Platinum
Bishop, J., & Co., Platinum Wks.
Lamp, Arc & Incandescent, Tungsten
General Electric Co.
Holz, H. A.
Lead Burners
Moore & Simonson
Leaded Zinc Oxide
New Jersey Zinc Company, The.
Lifts, Air Jet
Bethlehem Fdy. & Mach Co.
Schutte & Koerting Co.
Lithopone
New Jersey Zinc Company, The.
Locomotive Cranes
Brown Hoisting Machinery Co.
Locomotives, Gasoline
Fate, The J. D., Co.
Locomotives, Industrial
Fate, J. D., Co.
General Electric Co.
Lakewood Eng. Co., The.
Vulcan Iron Works.
Machinery, Agitating
Day, The J. H., Co.
Dorr Co., The.
Werner & Pfleiderer Co.
Machinery, Automatic Weighing
Pratt Eng. & Machine Co.
Schaffer Eng. & Equipment Co.
Werner & Pfleiderer Co.
Machinery, Classifying
Dorr Co., The.
Machinery, Coal Grinding
Aero Pulverizer Co.
Powdered Coal Eng. & Eqpt. Co.
Pratt Eng. & Machine Co.
Raymond Bros. Impt. Pulv. Co.
Williams Patent Crusher & Pulv. Co.
Machinery, Conveying & Elevating
Caldwell, H. W., & Son Co.
Guarantee Construction Co.
Link-Belt Company
Robins Conveying Belt Co.
Stephens-Adamson Mfg. Co.
Webster M'f'g. Co., The.
Machinery, Crushing, Grinding and Pulverizing
Abbé Eng'g Co.
Abbé, Paul O.
Aero Pulverizer Co.
American Pulverizer Co.
Colorado Iron Works Co.
Day, J. H., Co.
Dunning, W. D.
Hardinge Conical Mill Co.
K-B Pulverizer Co.
Johnson Eng. Works.
Kent Mill Co.
Mead & Co.
Mine & Smelter Supply Co.
Patterson Fdy. & Mach. Co.
Pratt Eng. & Machine Co.
Raymond Bros. Imp. Pulv. Co.
Sturtevant Mill Co.
Vulcan Iron Works.
Williams Patent Crusher & Pulverizer Co.
Worthington Pump & Machy. Corp.
Machinery, Crushing, Grinding & Pulverizing Lab'y
Abbé Eng'g Co.
Abbé, Paul O.
Braun Corporation, The.
Braun-Knecht-Heinmann Co.
Hardinge Conical Mill Co.
Sturtevant Mill Co.
Thomas Co., Arthur H.
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Colorado Iron Works Co.
Dorr Co., The.
Worthington Pump & Machy. Corp.
Machinery, Electrical
General Electric Co.
Lincoln Electric Co., The.
Machinery, Metallurgical and Mining
Abbé Eng'g Co.
Abbé, Paul O.
Aero Pulverizer Co.
American Process Co.
American Pulverizer Co.
Colorado Iron Works Co.
Dorr Co., The.
Dwight & Lloyd Sintering Co.
General Chemical Co., The.
Hardinge Conical Mill Co.
Johnson Eng. Works.
Kelly Filter Press Co.
K-B Pulverizer Co.
Kent Mill Co.
Lungwitz, E. E.
Mine and Smelter Supply Company, The.
Pacific Foundry Co.
Raymond Bros. Imp. Pulv. Co.
Ruggles-Coles Eng. Co.
Stearns-Roger Mfg. Co.
Sturtevant Mill Co.
Vulcan Iron Works.
Wedge Mechanical Furnace Co.
Worthington Pump & Machy. Corp.
Machinery, Mixing and Kneading
Abbé Eng'g Co.
Abbé, Paul O.
Buffalo Fdy. & Machy. Co.
Day, J. H., Co.
Dunning, W. D.
Mead & Co.
Patterson Fdy. & Mach. Co.
Pratt Eng. & Machine Co.
Sowers Manufacturing Co.
Werner & Pfleiderer Co.
Worthington Pump & Machy. Corp.
Machinery, Ore and Coal Handling
Brown Hoisting Machinery Co.
Guarantee Construction Co.
Link-Belt Company
Stephens-Adamson Mfg. Co.
Machinery, Ore Concentrating
Colorado Iron Works Co.
Dorr Co., The.
Kent Mill Co.
Ruggles-Coles Eng. Co.
Mine and Smelter Supply Company.
Worthington Pump & Machy. Corp.
Machinery, Refrigerating
Vogt, Henry, Machine Co.
Machinery, Screening
Link-Belt Company.
Stephens-Adamson Mfg. Co.
Webster M'f'g. Co., The.
Worthington Pump & Machy. Corp.
Machinery, Soap
Dunning, W. D.
Machinery, Special
Allbright-Nell Co., The.
Buffalo Fdy. & Machine Co.
Day, The J. H., Co.
Fulton Foundry Co.
Ruggles-Coles Eng. Co.
Stevens-Aylsworth Co.
Volta Mfg. Co., The.
Werner & Pfleiderer Co.
Machinery, Thickening and Dewatering
Dorr Co., The.
Werner & Pfleiderer Co.
Machinery, Transmission
Stephens-Adamson Mfg. Co.
Webster M'f'g. Co., The.
Machinery, Weighing
Schaeffer Eng. & Equipment Co.
Sturtevant Mill Co.
Werner & Pfleiderer Co.
Magnesite
American Mineral Production Co.
Brunt, H. H., & Co.
Foote Mineral Co.
Harbison-Walker Refractories Co.
Magnesium Metal
Leavitt, C. W., & Co.
Norton Laboratories, Inc.
Magnetic Pulleys
Dings Magnetic Separator Co.
Magnetic Separators
Dings Magnetic Separator Co.
Magnets
Dings Magnetic Separator Co.
Metal, Asbestos Protected
Asbestos Protected Metal Co.
Metallographic Apparatus
Holz, Herman A.
Palo Co.
Scientific Materials Co.
Metallo-Radiographic Apparatus
Holz, Herman A.
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Dorr Co., The.
Dwight & Lloyd Sintering Co.
Metals
Electric Smelting & Alum. Co.
Goldschmidt Thermit Co.
Lavino, E. J., & Co.
Leavitt, C. W., & Co.
Metals Disintegrating Co.
Meter Box Covers
American Cast Iron Pipe Co.
Cast Iron Pipe Publicity Bureau
Meters, Flow, Air, Gas Water
General Electric Co.
Spray Engineering Co.
Microscopes
Bausch & Lomb Opt. Co.
Palo Co.
Scientific Materials Co.
Thomas Co., Arthur H.
Mills, Ball, Pebble and Tube
Abbé Eng'g Co.
Abbé, Paul O.
Colorado Iron Works Co.
Hardinge Conical Mill Co.
Johnson Eng. Works.
Mead & Co.
Mine & Smelter Supply Co., The.
Patterson Fdy. & Mach. Co.
Mills, Conical
Hardinge Conical Mill Co.
Mills, Emery
Sturtevant Mill Co.
Minerals and Ores
Continuous Reaction Co., The.
Foote Mineral Co.
Lavino, E. J., & Co.
Leavitt, C. W., & Co.
Vanadium Alloys Steel Co.
Molybdenum Ore
Foote Mineral Co.
Monel Metal
Supplee-Biddle Hdwe. Co.
Montejus
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Motors, Electric
General Electric Co.
Lincoln Electric Co., The.
Muffles
Mine & Smelter Supply Co., The.
Russell Engineering Company.
Nitro Compounds
Newport Chemical Works, Inc.
Nozzles, Spray
American Blower Co.
Buffalo Forge Co.
Carrier Engineering Corporation.
Duriron Castings Co.
Schutte & Koerting Co.
Spray Engineering Co.
Nozzles & Jets, Stoneware
See Stoneware Chemical.
Oils, Flotation
See Flotation Oil.
Ore Bedding and Reclaiming Systems
Robins Conveying Belt Co.
Ores
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Oxide, Gas Purifying
Lavino, E. J., & Co.
Paint Pigment, Graphite
Acheson Graphite Co.
Paints, Acid Proof & Technical
Toch Brothers.
Pans, Vacuum
Badger, E. B., & Sons Co.
Blair, Campbell & McLean, Ltd.
Buffalo Fdy. & Mach. Co.
Detroit Heating & Lighting Co.
Devine, J. P., Co.
Kestner Evaporator Co.
Koven, L. O., & Bro.
Lummus, The W. E., Co.
Pfaudler Company, The.
Pratt Eng. & Machine Co.
Roos', August, Son.
Scott, Ernest, & Co.
Sowers Manufacturing Co.
Swenson Evaporator Co.
Werner & Pfleiderer Co.
Zaremba Co.
Patent Attorneys
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See Mills, Ball, Pebble and Tube.
Perforated Metal
Mundt, Chas., & Sons.
Photomicrographic Apparatus
Bausch & Lomb Opt. Co.
Pine Products
Pensacola Tar & Turpentine Co.
Standard Chemical Co.
Pipe, Cast Iron
American Cast Iron Pipe Co.
Cast Iron Pipe Publicity Bureau
Clow, James B., & Sons
Glamorgan Pipe & Foundry Co.
Lynchburg Foundry Co.
U. S. Cast Iron Pipe & Fdy. Co.
Warren Foundry & Machine Co.
Pipe Silica Ware
Thermal Syndicate, Ltd., The.
Pipe Silver
Wall Co., A. T.
Pipe & Fittings, Cast Iron, Acid Proof
Duriron Castings Co.
Lunkenheimer Co., The.
Pacific Foundry Co.
Pipe & Fittings, Copper
Badger, E. B., & Sons Co.
Lummus, Walter E., Co., The.
Ott, George F., Co.
Roos', August, Son.
Pipe & Fittings, Enameled, Acid Proof
Elyria Enameled Products Co.
Pfaudler Co., The.
Stuart & Peterson Co.
Pipe & Fittings, Lead, Tin or Silver Lined
Badger, E. B., & Sons Co.
Cleveland Brass Mfg. Co.
Lead Lined Iron Pipe Co.
Schutte & Koerting Co.
United Lined Tube & Valve Co.
Pipe & Fittings, Stoneware, Acid Proof
General Ceramics Co.
Graham, C., Chem. Pottery Wks.
Knight, Maurice A.
Robinson Clay Product Co.
U. S. Stoneware Co.
Pipe & Fittings, Wood
National Tank & Pipe Co.
Redwoods Manufacturers Company.
Pitch, Coal Tar
Barrett Co., The.
Platinum
American Platinum Works.
Baker & Co., Inc.
Bishop, J., & Co. Platinum Wks.
Palo Co.
Thomas Co., Arthur H.
Platinum, Wire, Sheet & Foil
Bishop, J., & Co., Platinum Wks.
Plug Cocks:
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Porcelain Ware
Bausch & Lomb Opt. Co.
Braun Corporation, The.
Braun-Knecht-Heinmann Co.
Guernsey Earthenware Co.
Herold China & Pottery Co.
Laboratory Supply Co., The.
Mine & Smelter Supply Co.
Pots, Cast Iron, Acid Proof
Bethlehem Foundry & Mach Co.
Buffalo Foundry & Machine Co.
Duriron Castings Co.
Fulton Foundry Co.
Moore, Sam'l L., & Son.
U. S. Cast Iron Pipe & Fdy. Co.
Werner & Pfleiderer Co.
Pots, Stoneware, Acid Proof
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Precipitants
Merrill Metallurgical Co.
Precipitators, Centrifugal
Schaum & Uhlinger, Inc.
Pulleys, Magnetic
Dings Magnetic Separator Co.
Pulverizers, Laboratory
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Pulverizing Machinery
See Machinery, Crushing, Grinding and Pulverizing.
Pumps, Acid or Acid Gases
Abbé Eng'g Co.
Duriron Castings Co.
Elmore, G. H.
Nash Engineering Co.
Pratt Eng. & Machine Co.
Schutte & Koerting Co.
Worthington Pump & Mach'y Corp.
Pumps, Centrifugal
Abbé Eng'g Co.
Chemical Pump & Valve Co., The.
Duriron Casting Co.
Elmore, G. H.
Pelton Water Wheel Co.
Wayte W. J., Inc.
Worthington Pump & Mach'y Corp.

What Advertisers Offer to Readers

Classified Index of Products Advertised in This Issue by Representative Manufacturers and Dealers

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Wayte, W. J., Inc.

Pumps, Gas, Liq. or Vacuum
Abbé Eng'g Co.
Beach-Russ Company.
Buffalo Fdy. & Mach. Co.
Connersville Blower Co.
Crowell Mfg. Co.
Devine, J. P., Co.
Nash Engineering Co., The.
Pratt Eng. & Machine Co.
Worthington Pump & Mach'y Corp.

Pumps, Rotary, Oil or Water
Abbé Eng'g Co.
Connersville Blower Co.
Pelton Water Wheel Co.
Worthington Pump & Mach'y Corp.

Pumps, Stoneware, Acid Proof
General Ceramics Co.
Knight, M. A.
U. S. Stoneware Co.

Pyrites
Lavino, E. J., & Co.

Pyrometers
Braun Corporation, The.
Braun-Knecht-Heimann Co.
Bristol Co., The
Brown Instrument Co.
Engelhard, Chas.
Holz, Herman A.
Hoskins Mfg. Co.
Leeds & Northrup Co., The.
Nehls, Carl, Alloy Co.
Palo Co.
Pyrolectric Instrument Co.
Sargent, E. H., & Co.
Schaeffer & Budenburg Mfg. Co.
Scientific Materials Co.
Shore Instrument Co.
Stupakoff Laboratories.
Taylor Instrument Companies.
Thomas Co., Arthur H.
Thwing Instrument Co.
Uehling Instrument Co.

Pyrometer Installations
Holz, Herman A.
Stupakoff Laboratories.

Pyrometer Paste
Nehls, Carl, Alloy Co.

Pyrometer Protection Tubes
Engelhard, Chas.
Herold China & Pottery Co.
Stupakoff Laboratories.
Thermal Syndicate, Ltd., The.

Pyrometer Sheets, Graphite
Acheson Graphite Co.

Pyroscope
Shore Instrument Co.

Quartz Glass
See also Fused Silica
Engelhard, Chas.
Thermal Syndicate, Ltd., The

Railways, Industrial & Portable
Easton Car & Construction Co.
Lakewood Engineering Co.

Recorders, CO_2
Uehling Instrument Co.

Recording Instruments, Pressure, Temperature, Electricity, Motion, Speed, Time
Bristol Co., The.
Brown Instrument Co.
Engelhard, Chas.
Holz, Herman A.
Hoskins Mfg. Co.
Leeds & Northrup Co., The.
Pyrolectric Instrument Co.
Schaeffer & Budenburg Mfg. Co.
Taylor Instrument Companies.
Thwing Instrument Co.
Uehling Instrument Co.

Refractories
See Brick and Clay, Fire

Refrigerating Machinery
See Machinery, Refrigerating

Regulators, Automatic Humidity
American Blower Co.
Carrier Engineering Corp.

Regulators, Pressure
Connersville Blower Co.
Taylor Instrument Companies.

Regulators, Temperature
Sarco Company, Inc.
Taylor Instrument Companies.

Resistance Wire
See Wire, Resistance

Resistant Chemical Glassware
Fry, H. C., Glass Co.
International Glass Co., The

Respirators
American La France Fire Engine Co.

Retorts
See Acid Distillation Apparatus

Retorts, Graphite
Bartley, Jonathan, Cruc. Co.

Retorts, Vertical
Isbell-Porter Co.

Rolls
See Machinery, Crushing and Grinding and Pulverizing

Roofs, Walls, Partitions, etc., Concrete
Asbestos Protected Metal Co.

Roofings and Sidings—Fume Proof
Asbestos Protected Metal Co.
Brown Hoisting Machinery Co.

Safety Devices
American La France Fire Engine Co.

Safety Goggles
American La France Fire Engine Co.

Scales, Conveyor
Schaffer Eng. & Equip. Co.

Scales, Weighing
Sturtevant Mill Co.
Werner & Pfleiderer Co.

Scleroscope
Holz, Herman A.
Shore Instrument Co.

Screens
Colorado Iron Works Co.
Kent Mill Co.
Multi-Metal Separating Screen Co.
Mundt, Chas., & Co.
Patterson Fdy. & Mach. Co.
Sturtevant Mill Co.
Worthington Pump & Machy. Corp.

Screens, Chain
Codd, E. J., Co.

Screen Doors
Codd, E. J., Co.

Screening Machinery
See Machinery, Screening

Separators, Air
Aero Pulverizer Co.
Pratt Eng. & Machine Co.
Raymond Bros. Imp. Pulv. Co.
Williams Patent Crusher & Pulverizer Co.

Separators, Centrifugal
Schaum & Uhlinger, Inc.
Sharples Specialty Co.
Tolhurst Mach. Wks.

Separators, Magnetic
Dings Magnetic Separator Co.

Separators, Steam and Oil
Braemer Air Conditioning Co.

Silent Chain
Link-Belt Company

Silos, Wood
National Tank & Pipe Co.
Redwood Manufacturers Company.

Silver Piping
See Pipe, Silver

Silver Rod, Sheet and Solder
Wall, A. T., Co.

Sintering Processes
Dwight & Lloyd Sintering Co.

Spelter, Spiegeleisen
New Jersey Zinc Company, The.

Spray Nozzles
See Nozzles, Spray

Soldering & Brazing Outfits, Acetylene
Prest-O-Lite Co.

Sprocket Wheels
Link-Belt Company

Steel, High Speed
Standard Alloys Co.

Stills, Chemical
See Distilling Machinery and Apparatus

Stirrers, Acid Proof
Acheson Graphite Co.
Duriron Castings Co.
Werner & Pfleiderer Co.

Stokers
Hagan, Geo. J., Co.
Laclede-Christy Clay Products Co.

Stoneware, Chemical, consisting of
Bottles, Carboy Stoppers, Coils and Worms, Crystallizing Dishes, Chlorine Generators, Decanting Pots, Dippers, Dipping Dishes, Faucets, Funnels, Kettles, Mortars and Pestles, Nozzles and Jets, Pots and Jars, Pitchers, Retorts, Receivers or Woulff Bottles, Sinks, Storage Jars, etc.
General Ceramics Co.
Graham, C., Chem. Pot'ry Wks.
Knight, M. A.
Robinson Clay Product Co.
U. S. Stoneware Co.
Weeks, A. J.

Stopper Heads
Bartley, Jonathan, Crucible Co.

Sulphur Burners
See Burners, Sulphur

Sulphur, Crude
Union Sulphur Co., The.

Sulphur Dioxide, Liquid
Ansul Chemical Co.

Sulphuric Acid Plants
Kalbperry Corp., The.

Switchboards
General Electric Co.
Westinghouse Electric & Mfg. Co.

Syphons, Acid, Stoneware
Knight, M. A.
U. S. Stoneware Co.

Syphons, Metal
Schutte & Koerting Co.

Tachometers
Foxboro Co.
Schaeffer & Budenburg Mfg. Co.

Tanks, Cast Iron
Detroit Range Boiler Co.
Stevens-Aylsworth Co.

Tanks, Copper
Badger & Sons Co., E. B.
Detroit Heating & Lighting Co.
Lummus, The W. E., Co.
Ott, George F., Co.
Roos' Son, August

Tanks, Cyanide
Redwood Manufacturers Company.

Tanks, Enameled, Acid Proof
Elyria Enameled Products Co.
Pfaudler Co., The.
Stuart & Peterson Co.

Tanks, Lead Lined, Acid Proof
Blair, Campbell & McLean, Ltd.
Caldwell, W. E., Co.
Eagle Tank Co.
United Lined Tube & Valve Co.

Tanks, Steel
Aetna Steel Products Co.
Baltimore Co., The.
Caldwell, W. E., Co.
Codd, E. J., Company.
Detroit Range Boiler Co.
Hamburg Boiler Works.
Kellogg, The, M. W., Co.
Koven, L. O., & Bro.
Manitowoc Engineering Works.
Prest-O-Lite Co.
Stevens-Alysworth Co.
Stevens Brothers.

Tanks, Stoneware, Acid Proof
General Ceramics Co.
Graham, C., Chem. Pot'y Works.
Knight, Maurice A.
U. S. Stoneware Co.
Weeks, A. J.

Tanks, Wood
Baltimore Co., The.
Caldwell, W. E., Co.
Challenge Company.
Corcoran, A. J., Inc.
Eagle Tank Co.
Hauser-Stander Tank Co., The.
Kalamazoo Tank & Silo Co.
National Tank & Pipe Co.
Redwood Manufacturers Company.
Schwarzwalder, J., & Sons
U. S. Wind Engine & Pump Co.

Testing Laboratories
See Professional Directory, Pages 114, 115.

Testing Machines, Metal
Holz, Herman A.
Shore Instrument Co.

Testing Sieves
Multi-Metal Separating Screen Co.

Thermit
Goldschmidt Thermit Co.

Thermocouples, Platinum
Holz, Herman A.

Thermometers
Bristol Co., The.
Bausch & Lomb Opt. Co.
Engelhard, Chas.
Foxboro Co.
Gaertner, Wm., & Co.
Griebel Instrument Co.
Leeds & Northrup Co., The.
Palo Co.
Pyrolectric Instrument Co.
Schaeffer & Budenburg Mfg. Co.
Taylor Instrument Companies.
Thwing Instrument Co.

Thermostats
Sarco Company, Inc.

Titanium
Goldschmidt Thermit Co.
Titanium Alloy Mfg. Co.

Titanium Ores
Foote Mineral Co.
Titanium Alloy Mfg. Co.

Tool Steel
Standard Alloys Co.

Tower Packing, Acid Proof, Stoneware
Knight, M. A.
Laclede-Christy Clay Products Co.
U. S. Stoneware Co.

Towers, Acid
Duriron Castings Co.

Towers, Acid, Stoneware
General Ceramics Co.
Graham, C., Chem. Pot'y Wks.
Knight, Maurice A.
U. S. Stoneware Co.

Tracks, Industrial and Portable
Easton Car & Construction Co.
Lakewood Engineering Co.

Transformers
American Transformer Co.
General Electric Co.
Kuhlman Electric Co., The.
Thordarson Electric Mfg. Co.
Westinghouse Electric & Mfg. Co.

Transformers, Special & Precipitation Process
American Transformer Co.
Kuhlman Electric Co., The.
Thordarson Electric Mfg. Co.

Transits
Ainsworth, Wm., & Son.

Traps, Steam & Radiator
Sarco Company, Inc.

Trolleys, I Beam
Brown Hoisting Machinery Co.

Tube Mills
See Mills, Ball, Pebble, Tube

Tungsten Ores
Continuous Reaction Co., The.
Vanadium-Alloys Steel Co.

Turntables, Industrial Railway
Easton Car & Construction Co.
Lakewood Engineering Co.

Uranium Alloys
Standards Alloys Co.

Vacuum Drying Apparatus
See Dryers, Vacuum

Vacuum Filters
See Filters, Vacuum

Vacuum Pans
See Pans, Vacuum

Vacuum Pumps
See Pumps, Gas, Liquid or Vacuum

Valves and Cocks, Metal, Acid Proof
Chemical Pump & Valve Co., The.
Cleveland Brass Mfg. Co.
Duriron Castings Co.
Lead Lined Iron Pipe Co.
Lunkenheimer Co., The.
Pacific Foundry Co.
Pratt Eng. & Machine Co.
United Lined Tube & Valve Co.

Valves and Cocks, Stoneware, Acid Proof
General Ceramics Co.
Graham, C., Chem. Pot'y Wks.
Knight, Maurice A.
U. S. Stoneware Co.

Valves, Vacuum
Sarco Company, Inc.

Vanadium Alloys
Standard Alloys Co.

Vats, Metal, Acid Proof
Duriron Castings Co.

Vats, Stoneware, Acid Proof
See Stoneware Chemical

Vats, Wood
Caldwell, W. E., Co.
Challenge Company.
Eagle Tank Co.
Redwood Manufacturers Company.
Schwarzwalder, J., & Sons, Inc.
U. S. Wind Engine & Pump Co.

Viscosimeter
Bausch & Lomb Optical Co.

Wagon Loaders
Link-Belt Company

Waterproofing Compound (Liquid)
Anti-Hydro Waterproofing Co.

Water Tanks and Towers
See Tanks, Wood and Tanks, Steel

Water Wheels
Pelton Water Wheel Co.

Weighing Machinery
See Machinery, Weighing

Weighing Machinery, Automatic
See Machinery, Automatic Weighing

Welding and Cutting, Oxy-Acetylene
Prest-O-Lite Co.

Welding Materials
Acheson Graphite Co.
General Electric Co.
Goldschmidt Thermit Co.
National Carbon Co.
Prest-O-Lite Co., The.

Welding Outfits, Arc
General Electric Co.
Lincoln Electric Co., The.

Welding Thermit Process
Goldschmidt Thermit Co.

Winches, Electric
Volta Mfg. Co., The.

Wire Cloth
Multi-Metal Separating Screen Co.

Wood Distillation
Apparatus, for
Badger, E. B., & Sons Co.
Blair, Campbell & McLean, Ltd.
Devine Co., J. P.
Lummus, The W. E., Co.
Manitowoc Engineering Works.
Zaremba Co.

Wood Pipe
See Pipe and Fittings, Wood

Wood Tanks
See Tanks, Wood

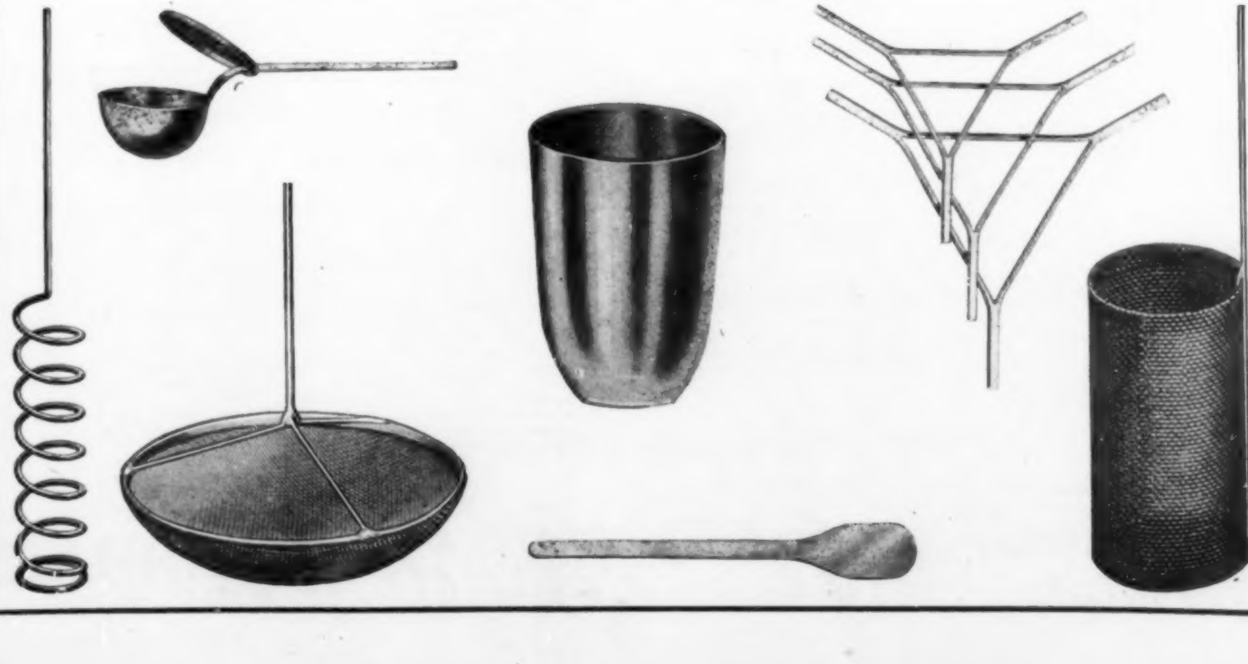
Zinc
Braun Corporation, The.
Braun-Knecht-Heimann Co.
Metals Disintegrating Co.
New Jersey Zinc Company, The.

Zinc Dust
Braun Corporation, The.
Braun-Knecht-Heimann Co.
Merrill Metallurgical Co.
New Jersey Zinc Company, The.

Zinc Oxide
New Jersey Zinc Company, The.

Zinc Stripe
New Jersey Zinc Company, The.

Zirconia
Foote Mineral Co.



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Change of copy for standing advertisements, where proof is not necessary, must be received not later than eight days before date of issue.

New Advertisements (not changes of copy) received five days before date of issue can usually be inserted.

Searchlight Advertisements (Wants, For Sale etc.) received four days before date of issue will be published if space is then available.

If Proofs are Required before printing, changes of copy should be in our hands two weeks in advance of date of publication. The paper is dated the 1st and 15th, but is out the day before.